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The Weather Bureau has not enough of the following numbers of the MONTHLY WEATHER REVIEW to meet even urgent requests for filling up files at institutions where the REVIEW is constantly being referred to. The return of any of these or of any 1919 or 1920 issues, especially November, 1919, will be greatly appreciated. An addressed franked slip may be had on application to the Chief, U. S. Weather Bureau, Washington, D. C.

1914: January, February, March, April, September, October, December.
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1918: February, September.
1919: Any issue, especially November.
1920: Any issue, especially January.
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CHANGES IN MONTHLY WEATHER REVIEW CHARTS AND SECTIONS.

Beginning with this issue four small inset charts will appear, one each on charts Nos. II, III, V, and VIII. The inset chart on No. II will give the departure of the monthly mean pressure from the normal; the inset on No. III will give the average change in pressure, increase or decrease, between the current and preceding months; the inset on chart No. V will show the departure of precipitation from the normal; the inset on chart No. VIII will show the depth of snow on the ground at end of month.

Changes in titles on Charts II and III are the adoption of the terms anticyclones and cyclones for HIGHS and LOWS, respectively. Chart No. IV will show departure of data for Canadian stations regularly hereafter, although owing to difficulties in transmission of mail reports from some of the most distant of those stations it may happen that the data may not always be complete for any given month.

In addition to the changes in charts, there is to be a monthly discussion of aerological conditions by Mr. W. R. Gregg. This discussion will appear in the section on "Weather of the Month" and will follow "Cyclones and Anticyclones." Mr. Gregg's section is to be known as "Free-air conditions."—EDITOR.

THE WEATHER ELEMENT IN RAILROADING.[1]

By GUY H. BURNHAM.

[Clark University, Worcester, Mass. Jan. 31, 1922.]

SYNOPSIS.

Railroading in every clime has important weather problems to meet and overcome, for trains and tracks have no protection against the various elements of nature. First of all, temperature extremes have a racking effect upon all steel and iron work. Rails and car wheels, exposed to such severe meteorological conditions, often break and delays sometimes result. To overcome these troubles, steel made by the open-hearth process is being used with good results.

Of the various forms of precipitation snow is regarded as the great enemy of rail transportation. Each year millions of dollars are spent in fighting the battle against snow, for windbreaks of various sorts must be erected, snowplows of different types manned and equipped, and miles of snowsheds constructed. Heavy rains bring about floods which wash away bridges, undermine roadbeds, and cause landslides. Abundant rainfall also produces luxuriant vegetation, which is a great nuisance on earth ballasted roads; for, unless cleared from the tracks, train operation is rendered difficult. Moisture also greatly reduces the life of ties and other woodwork; and to combat this effect, expensive preservative processes have to be introduced. Sleet storms and thundershowers often put electrified lines out of commission and thus create problems for the electrical engineer to solve.

Wind is an important factor in railroading, for trains are sometimes derailed by high winds. Snow and sand impelled by strong winds drift on the track, often delay transportation, and bring many difficult problems for railroad engineers to solve.

The weather affects not only the track and rolling stock of the railroad, but also the goods which it transports. This is especially true of the transportation of perishable goods in which temperature is the all-controlling factor. To regulate properly the temperature of perishable goods in transit, precooling and icing stations have been built and refrigerator and heater cars have been invented. To the efficiency of these various agencies we owe the safe transportation of many of our staple food products.

INTRODUCTION.

To the railroad man, the various phases of the weather—the rain, the sleet, the snow, the hot days, the cold days—have a significant meaning, for each brings with it special problems which have to be met and overcome. Upon the solution of these problems much depends, for the railroad is such an indispensable agent in modern life that its service must be kept up to the highest possible efficiency. In the olden days our forefathers procured life's necessities in the communities in which they lived—the town gristmill supplied the flour; clothes for the family were the product of the spinning wheel, and shoes were made from hides tanned at home. The primitive community thus was able to take care of its ordinary wants; and because of the poor means of communication then existing, but little intercourse was carried on with the outside world. As time went on roads were built between the various communities, canals were dug, rivers widened, commerce began to spring up, and the horizon of man broadened somewhat. The greatest developments along this line, however, have occurred within the last hundred years and have been mainly due to two agencies of transportation—the steamship and the railroad. To-day we look to distant lands for the sources of raw material for our factories and we talk of world markets for our goods, all of which would seem like a dream to our ancestors and which would be impossible had it not been for the application of steam as a propelling agency to land and water transportation. These two modes of transportation are now found in all parts of the world and hence the varied weather conditions which they have to face have far-reaching economic results. The problems connected with water transportation while very interesting are not so complex as those related to railroading and hence we shall confine our discussion entirely to the latter in this paper.

Although railroads are found in nearly every clime from the frozen plains of the north to the tropical jungle, their greatest developments have been reached in the temperate zones. The building of these roads, now largely a matter of history, gives us many a heroic tale of how mighty rivers were bridged, towering mountains overcome, and huge forests penetrated. To-day the story of railroading is largely one of a battle against the elements of nature to

[1] Thesis submitted in course on meteorology at Clark University.

keep the roads running—heavy rains wash away bridges, ballast, and track; rot ties and cause landslides; drifting sand dunes often interrupt the service; snow blocks the tracks and prevents the operation of trains; sleet often puts electrified lines out of commission; and extremes of heat and cold not only raise havoc with the rails and locomotives but also do considerable damage, unless precautionary measures are taken, to perishable goods in transit.

Our problem then naturally divides itself into two parts—the effects of the weather upon the roadbed and rolling stock and its effects upon the goods transported. We shall now discuss each in detail.

THE WEATHER ELEMENTS IN MAINTENANCE OF WAY AND ROLLING-STOCK PROBLEMS.

In railroading man has to furnish not only the vehicle but also the highway; and since both have to withstand the attacks of nature, the railroader finds himself constantly facing many problems that never appear to those engaged in other lines of transportation. The solution of these problems, which entail upon the railroads large upkeep costs, becomes largely a struggle against the various weather elements. The story of this battle as we shall soon see is very interesting.

Temperature is an important element in railroading. Extremes of heat and cold have a racking effect upon rails, girders, and other ironwork and careful allowances have to be made for this factor. Since steel when heated tends to expand, most railroads have track regulations which require foremen to pay particular attention to this element, the allowance to be made depending upon the season of the year in which the rails are laid. All track manuals have tables which provide for allowances of $\frac{5}{16}$ of an inch during coldest weather; $\frac{1}{8}$ of an inch during spring and fall, and $\frac{1}{16}$ of an inch during the hot summer months.[2] Such general rules as this have been evolved as a guide because of the difficulty of determining the real temperature of the rail when laid. When followed, good results are obtained and buckling due to expansion rarely occurs. In bridge construction, engineers have to make similar allowances, the girders never being solidly embedded in the concrete abutments.

The racking effects of temperature upon rails are further brought out by the large breakages which often occur during the winter season. Commenting upon this point, Dr. P. H. Dudley, of the New York Central lines, says: "The winter of November, 1911–12, had deficiency temperatures and the rails contracted in the splice bars. December had excess temperatures and the rails reexpanded partially in the splice bars. The cold wave commenced one or two days in the last of December but January was cold and in most places February and March. In that winter the railroads had the greatest epidemic of broken Bessemer steel rails, with 0.10 phosphorous that they ever experienced.[3] Such great breakages due to the large phosphorus content of the Bessemer steel and the severe meteorological conditions caused the railroads to turn to rails made by the open-hearth process. Time has proven that these rails with their low phosphorus content of 0.03 on the average stand up better than the Bessemer type under severe temperature conditions. To quote Dr. Dudley again "The winter of 1917–18 was cold but the breakages due to the cold wave in the basic open-hearth rails were not one-twentieth that they were in the winter of 1911–12." But few breakages in the same type of rail occurred in the severe winter of 1919–20 and Dr. Dudley has come to believe that these rails will stand under the heavy traffic of the New York Central lines cold waves of 40° below zero with hardly any rails breaking.

The good results obtained with the rails also led to the making of solid steel car wheels by the same method. Defects and breakages were thereby lessened and tests have proven that these wheels can withstand the severe meteorological conditions to which they are put better than any wheels previously made.

Authorities upon this subject seem to be agreed that while the open-hearth process is a more expensive way of making steel, the product is better able to endure the severe temperatures to which it is subjected. Hence we find rails and car wheels made in this way replacing those made by the Bessemer process. By following this replacement plan the railroads believe that they will be better equipped to combat the effects of that all important weather element—temperature.

The combination of a cold wave and a defective car wheel causes many rail breakages. Haines says on this point: "During the severe winter weather in January and February, 1912, many rails on lines in the Northwest were broken by flat wheels. On a line in Minnesota a 4-inch flat spot on a rolled steel wheel in passenger service broke nine 80-pound rails in a distance of 3 miles."[4] Thus rails that ordinarily would withstand severe temperatures succumb to the strain resulting from the above conditions. Railroads are spending thousands of dollars annually in maintaining an efficient inspection service in an effort to overcome this difficulty.

Low temperatures combined with moisture in a dirt roadbed form ice which heaves the track and causes rails to spread. A crushed stone ballast does away with these troubles. Besides overcoming the ice dangers, it also forms a dustless roadbed which is of decided advantage in dry weather. Up-to-date lines have ballasted miles of their roadbed in this expensive fashion and have thus been able to operate their trains in a more efficient manner.

It has also been found that low temperatures tend to double the rolling friction of freight and passenger trains. This, together with the increased head resistance which is due to the greater density of the cold air, furnishes the chief reason why train tonnage must be cut down in the winter. Thus these factors along with the trouble of making steam in cold weather explain why heavy trains often have great difficulties in starting out of stations during the cold months of the year.

Precipitation in its varied forms is probably the most important weather element with which the railroad man has to contend. In the United States snow is particularly hostile to rail transportation and various methods have been devised by the railroads to combat it. The problem of handling snow becomes more difficult when wind enters in as a factor, for the snow, impelled by the high wind, piles up in huge drifts. "Bucking the drifts" is a great winter pastime among the railroad men of the United States. To overcome the evils of drifting snow, the railroads in many parts of the country put up each autumn wooden fences in the fields along their right of ways where drifts are likely to occur. These fences are usually from 4 to 6 feet high and consist of boards nailed 3 or 4 inches apart on heavy wooden posts. They

[2] For complete table see F. J. Prior: "Construction and Maintenance of Railway Road bed and Track," Appendix F, p. 562.

[3] Information furnished by Dr. P. H. Dudley, consulting engineer rails, tires and structural steel, New York Central lines.

[4] H. S. Haines, Efficient Railway Operation, Appendix 5, p. 569.

serve as a very efficient barrier to snow driven along by high winds for "by breaking the force of the wind near the ground it causes the snow to be precipitated in a drift on the leeward side of the fence, leaving the track beyond relatively clear."[5] Many miles of these structures are set up every year and as thousands of feet of lumber are used in their construction, this one item alone looms big in the annual budget of snow removal expenditures.

In an effort to reduce their snow-fighting bills, some railroads have replaced these board fences with hardy quick-growing young trees of both evergreen and deciduous varieties. To secure the best results the trees are planted about 75 feet from the track in rows about 3 feet apart. The rows are set out in staggered formation and a space of about 3 feet is left between each tree. Experiments made with the various kinds of trees show that either two rows of conifers or eight rows of deciduous trees planted in this fashion will be equally effective. By following this plan, then, a good thick hedge is secured which increases in its effectiveness as a windbreak as the years roll by. Wherever this plan has been adopted, it has worked so successfully that others have been induced to imitate it and hence we now find it being used almost exclusively by many roads in both the United States and Canada for "experience has shown that over a period of years, a snow fence of trees has a decided advantage over the old style board fence in respect to both efficiency and economy."[6]

The transcontinental lines that cross the Cascade Mountains of Washington and Oregon and the Sierra Nevadas of California have to contend with a snow problem of great magnitude. In these mountains the snow accumulates on level ground to a depth of 25 or 30 feet and drifts may be found in the canyons and gulches that are twice as deep. Here the locomotive push plow so common on the eastern roads gives way to the powerful rotary plow. This is "a very heavily constructed car, usually built of southern pine about 12 feet high. The front which cuts the snow and throws it aside looks like a giant dirt plow. On each side of the car are heavily built wings which can be let out or pulled in as desired by the application of air. When these wings are fully extended they reach out on each side about 6 feet from the body of the car. They have just the proper curvature and angle to curl the snow up and shoot it clear of a snow bank 12 or 14 feet high."[7] Thus it can be seen that in order to keep the tracks clear in this region of heaviest snowfall, such plows are an absolute necessity.

High up in the mountains even the rotaries are of no avail in keeping the iron trail open for travel and there snowsheds have been resorted to. These sheds are usually made of heavy timbers and are roofed over and serve as tunnels through which the trains may pass. They are designed to sustain snow 16 feet in depth and where that limit is reached, it is necessary to shovel the excess off by hand. In spite of their massive structure, sections of the sheds sometimes collapse and thus block transportation until the débris is cleared away. Some of the best-known snow sheds in the world are on the Overland Route of the Southern Pacific. Here it was found necessary to construct 32 miles of snowsheds in order to operate this line during the winter months. These sheds were built "at a cost of $42,000 a mile over single track and $65,000 a mile over double track. On the average $150,000 a year is spent for upkeep and renewals, the expenditure for a typical year 1914 having been $65,000 for repairs and $91,000 for renewals."[8] In wooden sheds such as these, the fire hazard is very great. This necessitates the patrolling of the sheds every minute of the day and night and the maintenance of fire-fighting trains at convenient points. As soon as a fire breaks out, the track walker telephones to the nearest fire station and a train is rushed to the scene of the conflagration. Some railroads have tried to do away with this danger from fire by erecting concrete sheds but their initial cost renders this type of construction almost prohibitive. "On the Great Northern," for example, "for 10 miles down the western slope at the end of the Cascade Tunnel, 76 per cent of the distance has been protected at a cost of nearly $1,500,000. These sheds have concrete retaining walls and a timber roof designed for a load of 1,500 pounds per square foot."[9]

Besides actually impeding traffic, snow is sometimes a costly factor in operation in that it occasionally causes destructive slides. These slides not only sweep snowsheds and track away but sometimes hurl a train to destruction. Thus "On January 22, 1916, a snowslide struck an all steel passenger train near Corea, Wash., cutting it in two and sweeping several coaches into the ravine below with the resultant loss of several lives."[10] The New York *Evening Post* of February 4, 1922, contains a dispatch from Tokyo, Japan, describing an accident, in which 110 lives were lost and numbers of persons injured when a train was struck and buried by an avalanche. Since the former accident the United States Weather Bureau has been making a study of snowslide conditions with the idea of being able to warn railroads when they are likely to occur and thus prevent such fatalities.

Snow is the enemy of transportation not only in the mountains and country districts but also in the great city terminals. Here the maze of switches, signal apparatus, and turntables becomes blocked and frozen and delays often result. Several methods are employed to thaw them out, the most common being steam, gasoline, and electric heating devices. Coal in hopper-bottom cars often arrives at destination frozen in the car. This is due to the alternate freezing and thawing of the snow on top the load. Delays and inconveniences often follow the freezing of the load, for it is very hard to get the frozen coal out of the car. To overcome all this, steaming sheds for thawing out the loads have been built in the larger terminals.[11] From the above discussion it can be seen that the battle against snow costs the railroads of the United States millions of dollars each year. Conservative estimates place these costs in an ordinary winter at between five and six millions dollars. In a severe winter it is safe to say that they would be several million more. Time will not permit us to tell the story of this costly impediment to transportation in other countries of the world, but suffice it to say that snow is a source of constant worry to the railroad man throughout the Temperate Zone.

In New England the ice storm of November, 1921, is still vivid in the minds of the railroad men. Trolley lines were, on the whole, hit the hardest as feed wires and high-tension cables fell under the weight of the masses of ice that collected upon them, and thus many lines were

[5] Snow and Railway Transportation, A. H. Palmer, Mo. WEATHER REV., Oct., 1919, p. 698.
[6] Literary Digest, Apr. 17, 1920. Article "Trees as Snow Fences," pp. 156-157.
[7] F. J. Prior, Construction and Maintenance of Railway Roadbed and Track, p. 223.
[8] Snow and Railway Transportation, A. H. Palmer, Mo. WEATHER REV., October, 1919, p. 698.
[9] H. S. Haines, Efficient Railway Operation, p. 264.
[10] Snow and Railway Transportation, A. H. Palmer, Mo. WEATHER REV., October, 1919, p. 699.
[11] Mo. WEATHER REV., March, 1919, p. 171.

put entirely out of commission. Railroad service was, however, badly disrupted and trains were hours late because their crews had to stop to remove poles and trees that were strewn across their path. The Boston & Albany Railroad tried to keep its right of way clear of these obstacles by having the tracks patrolled by wrecking crews. So many trees and poles fell, however, that they were unable to cope with the situation and it became impossible to keep the trains on schedule time. The situation was also rendered more acute by the crippling of block-signal systems and the freezing of switches and turntables. Surely this storm will long be remembered by the railroad men of New England.

Glaze raises havoc with electrified lines. These lines draw their power from either overhead-wire contacts or third-rail contacts, and when these become coated with ice, train movement is impeded and rendered almost impossible. In the overhead construction, the danger from falling wires is obvious. On western roads where rotary snowplows are used, overhead conductors and the supporting insulators are subject to a heavy bombardment of snow, ice, and refuse with possible resultant breakage. The top-contact-third-rail is the simpliest form of the third-rail type of contacts and even when guarded can not be wholly protected from snow and ice. As its lower part is only about 4 inches above the tie the danger of grounding from wet sbow and ashes and from flooding is very evident. This top contact arrangement was at first tried out on the electrified lines of the New York Central around New York City, but the various objections mentioned above led to its abandonment. The adoption of the undercontact rail followed. This rail is supported by insulators from brackets carried on the ties and is thus given a 9-inch clearance above the top of the tie. Glaze and snow do not seem to affect this rail very much as "very thorough tests made in connection with the New York Central work show satisfactory operation not only in sleet storms but also with the rail buried in snow." [12]. Glaze and snow when once frozen on the contacts, however, often give considerable trouble and sometimes threaten to tie up the operation of electric locomotives. To combat these effects, various methods have been devised, a favorite one being the spraying of the third rail with a chemical solution which will melt the icy coatings. Thus on the Long Island Railroad calcium chloride has done good work in this respect.[13] Experiments have been performed on various types of overhead wires with the idea of preventing the formation of glaze by keeping them above a freezing temperature, but whether or not they have been extended to the high tension circuits of electrified railroads I am unable to say. Temperature problems also have to be considered when dealing with overhead wires and the expansion and contraction of the same must be carefully provided for. The problem of the thunderstorm also furnishes food for thought. Severe thunderstorms seem to raise havoc with many electrified lines; the New Haven at times being especially hard hit. Thus with the entire electric division practically rendered useless by such storms, the New Haven can maintain its service only by falling back upon the old steam locomotive.

Such problems as the above seem to bear out the statements of Haines in his book on "Efficient Railway Operation," when he says that he believes that the electrified railroad is still largely an experiment and that many of its problems have not yet been correctly solved.[14]

Rain also does considerable damage to the railroads of the United States. This is especially true in the springtime when heavy rains together with melting ice and snow wash out gravel ballast and undermine tracks. Railroads have met this difficulty by replacing gravel ballast with crushed stone and by spending thousands of dollars for drainage systems for their right of way.

Where railroads pass through narrow cuts heavy rains often cause landslides. The writer personally remembers one such incident on the Portland division of the Boston & Maine Railroad, when traffic was blocked for several hours by a small landslide. To obviate this difficulty, the slopes of these cuts are being grassed over in an attempt to hold them in place. In some instances, also, retaining walls have been built.

The railroads in the Mississippi Basin probably suffer from excessive precipitation the most of any in the country. Heavy and frequent springtime rains often cause floods which completely demoralize the service of these roads. Thus, in 1903, service was generally disrupted by the carrying away of many railroad bridges. At Kansas City, Mo., for example, 16 out of the 17 bridges that cross the Missouri at that point were swept away. The one that remained withstood the flood only by being weighed down by 15 large locomotives which had been previously placed on the bridge.[15] Railroad tracks were generally torn to pieces by this flood, freight cars were smashed into bits, and many were carried down the river and huge locomotives were rolled over and over and were found buried several feet deep in the mud. The Missouri Pacific yards in Kansas City seemed to be the playground for the flood. Freight cars and shifting engines were scattered about, small buildings were completely wrecked, dead cattle and hogs were to be seen everywhere, as were piles of débris, which often mounted to a height of 40 feet. Thus it can be seen that the railroad property destroyed by these floods amounts to millions of dollars. This statement becomes more appalling when we look at the figures, the flood of 1913—a particularly destructive one—destroying railroad property valued at $16,168,565.[16]

Roads that pass through regions of heavy precipitation suffer greatly from weeds growing on the right of way. This is especially true in tropical countries, where "the roadway is constantly being overgrown, and men are kept at work cutting down the weeds, underbrush, and trees. This involves great expense and seriously reduces the earnings of the roads. Recently tank cars which frequently spray the right of way with a strong poison have come into use, as on the Guayaquil-Quito line in Ecuador, and on the Tehuantepec Railroad.[17] In many parts of the Temperate Zone weeds growing on the right of way of earth-ballasted roads also present some difficulties. Thus in the United States "the Union Pacific Railroad has used a gasoline weed burner, which scorches off the vegetation, and the salt water of Great Salt Lake sprinkled over the roadbed has also been found to serve well as a weed destroyer." [18]

In regions of heavy precipitation we find that the moisture has a destructive effect upon ties and other woodwork and may also be instrumental in the oxidization of

[12] *Annual Report of Smithsonian Institution*, 1907, page 144, "Electric Trunk Line Operation."—F. J. Sprague.
[13] *Electric Railway Journal*, June 19, 1920, page 1344.

[14] Haines, "Efficient Railway Operation: Sections on Electrification," pp. 25-32; 73-89.
[15] U. S. Weather Bureau Flood Service Bulletin M, The Flood of the Spring of 1903 in the Mississippi Watershed, p. 57.
[16] *Bulletin Z.* U. S. Weather Bureau, Flood and River Service, p. 42.
[17] R. DeC. Ward: *Climate*, p. 249.
[18] R. DeC. Ward: *Climate*, p. 315.

rails. In tropical and subtropical countries this seems to be very true, for there ties and trestles rot away very quickly. Thus "in Central America several bridges of Oregon pine between Escuintla and Palin were considered unsafe shortly after construction. It is said that no wood will stand in that climate; ties must be renewed every eight months and telegraph poles rot off in six months."[19]

Such frequent replacement of ties greatly increases the operating costs of the roads and has forced engineers to devise some plans to increase the life of the tie. Preservatives such as creosote have been used to good advantage in countries like India; while in other countries special kinds of wood such as lignum-vitæ or camphor wood have been tried out with excellent results. This problem has also been met in some places by the introduction of steel ties. Thus on the Government railway system in Cape Colony 700,000 of these ties[20] have been used and have given much satisfaction.

In the United States the tie problem is also a big one; for as our forests are fast being depleted, we find good ties becoming very scarce and also very high in price. Thus the railroads realize that they must adopt a policy of conservation and use every effort to increase the life of the tie. While the ties used by the United States railroads have a longer period of usefulness—the average ranging from about 3 years for hemlock to 15 years for the redwoods—experts are trying to add to their life's span. Experiments have proven that in order to do so the wood must be subjected to processes that will overcome the effects of moisture. These processes consist of treating the wood with various solutions, such as zinc chloride and zinc creosote. Large and expensive plants have been erected by the various railroads for this purpose. The Chicago & North Western Railway, for example, has two such plants devoted exclusively to the treatment of ties. "One of these has a capacity of 800,000 ties per annum and the other of 600,000; the timber being of pine, spuce or fir. In the more recent plant at Riverton, Wyo., the retort is 6 feet in diameter with a track of 24½ inch gage, admitting at one time a train of 16 cars each containing from 30 to 32 ties * * *. With four charges in 24 hours, the average output is about 50,000 ties per month."[21]

As to the results which this process achieves, the following quotation from Prior's *Manual* gives us much enlightment, "The Atchison, Topeka & Santa Fe Railway officials, after more than 15 years' trial on a large scale, believe they are getting from 11 to 12 years service from mountain pine having a natural life of about 4 years, while from natural (untreated) white oak they get but 6 years in heavy main line service and from cedar 10 years under light service."[22]

Steel ties have been but little used as substitutes for wood in the United States. The only road using them to any extent is the Bessemer and Lake Erie where up to 1913, 850,000 of them[23] had been put into service. To protect these ties from weathering, a coat of hot tar is given them before they are placed in the roadbed.

Precipitation also has some marked effects upon rolling stock. The slippery condition of the rails brought about by the effects of rain, sleet, and snow greatly impairs train efficiency and necessitates the use of sand in large quantities. Under such conditions locomotive tires become worn very quickly and their period of usefulness is greatly reduced.

Droughts are also a source of worry to the railroad man. In the United States, in extremely dry seasons many fires along railroad right of way are kindled by sparks from locomotives, and thousands of acres of valuable timber are destroyed in this fashion each year. Dry seasons also have their effects upon railroads which depend upon hydroelectric power for their operation. Thus in the dry season of 1920 many electrified lines in California were obliged to curtail operations on this account. In the Tropics, dry seasons disturb railroad operation by their effects upon woodwork. Ties, both treated and untreated, which have withstood the previous rainy seasons often become splintered and wither away under the hot tropical sun.

We have already noticed how wind by causing snow to drift has become a factor for evil in railroading and we have seen the measures which have been adopted by various railroads in combating the same. When we turn to roads that pass through desert or sandy regions, we find similar obstacles in the shape of drifting sand to overcome. In the United States, railroads that are forced to follow the sandy shore line or river valleys have this problem to struggle with. Trees have been planted, board fences have been erected, and other methods similar to those used in handling drifting snow have been devised. Thus on the California coast the Southern Pacific Co. is waging a successful warfare against this problem by planting acacia trees and a coarse stout beach grass similar to that used on the dikes in Holland.[24] This plan has been followed by the Canadian Pacific along sandy portions of its line, while other railroads, especially those in the Columbia River Valley, have resorted to the board fence as a means of checking the depredations of the drifting dunes.

Wind velocities also have to be taken into consideration by the structural engineer when he thinks of steel bridges, and the effects of wind resistance must be calculated by yardmasters when making up their trains on days when gales are blowing.

Railroad accidents are often caused by heavy winds, and service is sometimes suspended when the gale attains high velocities. Thus in Ireland on the West Claire Railway, a narrow gage road running from Ennis to Kilkee, heavy westerly gales have often derailed trains. At first, the engineers tried to break the force of the wind by building banks on the windward side of the road, but these proved of no avail. "Finally a pressure-tube anemometer was installed to give warning of winds of dangerous velocity by ringing a bell in the station master's house. Two warnings are given; the first when the instrument indicates 65 miles an hour and the second when the velocity rises to 85 miles an hour. When the first warning has been given, 2,400 weight of movable ballast, kept for the purpose at every station, are put on each car of the train, this being amply sufficient to prevent an overturn. If the second warning comes, the trains are stopped until the storm abates."[25] Such accidents sometimes occur in the United States although nowadays with the heavy equipment they are very rare. However in September, 1921, at Sioux Falls, S. D., a thundersquall blew a train of about 50 empty stock cars from the track.[26] (See figure 1.)

[19] R. M. Brown: Climatic Factors in Railroad Construction and operation, *Journal of Geography*, April, 1903, p. 229.
[20] H. S. Haines: Efficient Railway Operation, p. 229.
[21] H. S. Haines: Efficient Railway Operation, p. 223.
[22] F. J. Prior: Construction and Maintenance of Railway Roadbed and Track, pp. 265-266.
[23] H. S. Haines: Efficient Railway Operation, p. 229.

[24] U. S. Geological Survey Bulletin No. 614, pp. 110-111.
[25] *Symons's Meteorological Magazine*, March, 1916.
[26] Information furnished by C. F. Allen, traveling salesman for the Dymond Simmons Hardware Co., an eyewitness.

THE TRANSPORTATION OF PERISHABLE GOODS.

No discussion of the weather element in transportation would be complete without a word about the handling of perishable freight. Since a large bulk of our staple food products are classified under this head, this problem has vital interest for each and every one. Goods of a perishable nature are very susceptible to damage through temperature changes. To guard against such damage and to keep the goods in a salable condition are duties that belong to refrigerator-car companies, fast-produce express lines, and railroad freight-traffic departments. This burden of responsibility which rests upon their shoulders becomes very great because of the flitting fancies of the weather and the sudden changes of temperature.

In an attempt to overcome these conditions, and thus increase their efficiency in the transportation of perishables, railroads have built and equipped large and expensive icing plants at all the principal terminal and junction points in the country. These plants are so located that whenever a car needs icing it can be switched to one of them and have its bunkers filled very quickly. Besides icing plants, many railroads, particularly in fruit-growing districts, own large precooling stations. Such plants have been erected by the Southern Pacific Co. at Roseville and Colton, Calif. We shall soon see how precooling greatly increases the efficiency of the refrigerator car.

The transportation of perishable goods also involves large investments in refrigerator cars. There are in the United States about 140,000 refrigerator cars,[27] most of which are owned by private car companies. These companies are controlled largely by the packing and fruit-growing interests. The cars themselves are well made and will safely transport goods even at low temperatures. "The better class of refrigerator cars will carry all perishable goods safely through temperatures as low as 20° (F.) below zero provided they are not subject to such temperatures longer than three or four days at a time."[28] With ordinary refrigerator cars, which are not so well constructed, a temperature of zero is considered the danger point for most perishable goods.

Some cars of the ordinary box-car type have been lined with matched boards and provided with heaters. These cars are known as heater cars and are considered especially well adapted to the shipment of potatoes in the fall and winter months. Goods shipped in these cars will stand an outside temperature of 20° below zero when a man is in charge to keep up the fires.

Cars with ventilated doors are quite commonly used by the market gardeners in the southern United States during the spring and summer months for the shipment of vegetables.

Sometimes during car shortages perishable goods are shipped in ordinary box cars. These cars are lined with paper and the goods are packed in straw or sawdust. Experience has generally shown that goods shipped in this way have reached destination safely as long as the outside air temperature remained between 20 and 50°. Because of the great risks involved, however, the practice of using these cars for such shipments is not generally recommended.

From the above statements we can see that railroads and refrigerator car companies have large sums of money invested in various types of equipment which are designed to protect perishable goods in transit. We shall now consider the transportation of some of these goods and see why this investment has been rendered necessary.

The packing, the dairy, the market-gardening, and the fruit-growing industries of the United States are especially dependent upon the railroads for their existence. The products of these various industries can find suitable markets only by being transported long distances in refrigerator cars, and their salability at destination depends largely upon the care given them in transit by the railroad men. Thus these various interests and the railroads are inseparably linked together.

In shipping fresh meats, the almost universal practice of the packers is to use refrigerator cars in which the temperature can be maintained at any desired degree. Fresh beef before shipping is usually chilled to a temperature of from 36 to 40° and then loaded into cars which have the same temperature as the chill room. When these cars are traveling long distances, especially in summer it often becomes necessary to re-ice them, the frequency depending on the prevailing temperature. Pork is more quickly injured by high temperatures than the other meats and hence requires greater care in shipping. Poultry in car-load lots is shipped in much the same way as fresh meat, while smaller shipments are made in containers which are covered with chipped ice and burlap. When the ice bunkers remain empty for any length of time, the temperature within the car rises, and this has a very deleterious effect upon the contents. During the writer's service as a claim inspector for a leading transportation company he was called in on several occasions to view beef cars that had been under insufficient refrigeration while in transit. The effects were always quite visible—bluish spots and mold could be seen on nearly every carcass in such cars. This meat could not find ready sale in the market and for the losses sustained thereon the railroad because of its failure to ice the car properly was always held responsible.

Fish are shipped from the various seaports by express and also by freight. When shipped by express they are packed in barrels with ice. Less-than-carload lots by freight are shipped in a similar manner, while carload lots are packed in bins built in the car and are thoroughly iced. Fish keep best while in transit at a temperature of about that of melting ice and hence for successful shipment this factor must be watched closely.

Dairy products also need careful attention while on the road. These products are usually handled in an expeditious manner by the roads which pass through the dairy sections of the Middle West, fast freight refrigerator service being regularly operated between these places and the eastern markets. Extremes of heat and cold are very injurious to cheese, while butter is seriously affected by being exposed to high temperatures. Proper refrigeration and the maintenance of a fairly stable temperature within the car are therefore very necessary if these shipments are to reach destination in first-class shape. Similar standards are also set for the proper handling of eggs and milk.

Potatoes are usually shipped in heater cars and are almost always accompanied by an attendant who looks after the fire. The stove is usually located in the center of the car between the doors and from this point the heated air flows out in all directions. Since these cars are very often improperly loaded and lined, the flow of heat is interfered with and the potatoes are often frozen. Investigations conducted by the United

[27] *Railway Mechanical Engineer*, August, 1919, p. 182.
[28] *U. S. D. A. Farmer's Bulletin 125*, p. 8.

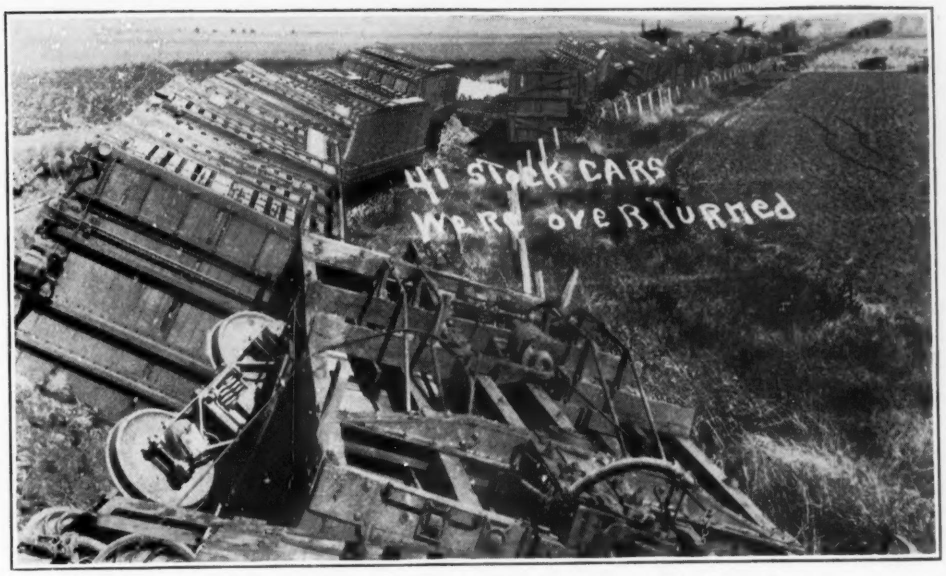

FIG. 1.—Train overturned by squall at Sioux Falls, S. Dak., September, 1921.

FIG. 2.—Bureau of Markets poster on proper loading of potatoes for shipment.

States Department of Agriculture showed that only one car in every four cars inspected was "so lined and loaded that the heater could properly protect the car even under ideal firing conditions." [29] The Government therefore recommends that this appalling situation be corrected by so lining and loading the cars that the warm air can circulate throughout the car and give an uniform temperature to the entire load. Figure 2 illustrates the correct methods they use in securing the above-mentioned conditions.

The citrus-fruit crop of California is one of the most important "perishables" that the railroads have to handle. Two methods are used in protecting these shipments while in transit—standard refrigeration and precooling. In the former, the fruit after being picked is carefully sorted and packed and then "loaded into a refrigerator car before either the fruit or the car has been artificially cooled, the boxes being so packed as to allow a free circulation of air between and around them. When shipments originate in southern California after being loaded, the car is usually taken to some assembling point, usually San Bernardino on the line of the Santa Fe or Colton on the line of the Southern Pacific and the bunkers are there filled with ice. As the car moves east the bunkers are opened from time to time and replenished with ice." [30] Experiments conducted with these cars have shown that during the first few days of the trip while the car is cooling down, the high temperature and great moisture often produce conditions which hasten ripening and decay. As a result of these investigations precooling was introduced. This system of refrigeration consists of preicing a refrigerator car—that is, "icing the car before loading or cooling the fruit before loading and loading into a preiced car." [30] Both carriers and shippers practice different methods of precooling; the essential difference being that in the former no attempt to cool the fruit is made until after it has been placed in the car. It has been found that cars shipped under this system require but little attention as regards icing in transit; in fact some cars have been known to make the trip from coast to coast without having their ice bunkers replenished. This saving of heavy icing bills and the better condition of the fruit upon arrival at destination seem to be the chief reasons for the adoption of this method by some of the orange growers.

Orange cars are equipped with ventilators which can be opened and closed at will. On the long trip across the continent, the position of these ventilators has to be changed several times to conform to the demands of the various climates through which the car must pass. This duty along with many others of a similar nature falls upon the train crew to whose charge the refrigerator cars are entrusted and it is to their zeal and efficiency that we owe the safe transportation of our orange crop.

The transportation of the other fruit and vegetable crops of the country from distant producing points to the large centers of consumption is also very interesting. The United States Department of Agriculture has conducted very thorough experiments in the shipping of many of these fruits and vegetables and the results which they have obtained therefrom give us much valuable information upon this subject. From these various investigations, we learn that the so-called summer fruits—the peach, the cherry, the plum, and the strawberry—are more subject to injury in transportation than are the fall and winter fruits. Hence it comes about that the railroads are handling these tender fruits with great care and dispatch. To give them quick movement to distant markets, special, through trains are often run from the growing regions to distant junction points, the Ozark strawberry specials of the Frisco lines being a particularly striking example.

Time will not permit us to go into the transportation of each of these various crops in detail. Suffice it to say, however, that you enjoy peaches from the orchards of Georgia, tomatoes from the far-away plains of Texas and strawberries from distant Louisiana as well as many another fruit and garden delicacy only because an efficient refrigeration service makes their transportation possible. In order to maintain this service at its highest efficiency the railroads often have to call upon the Weather Bureau for advice in regard to dangerous temperatures. When reports from the Weather Bureau indicate that perishable shipments already in, or traveling toward, a certain region are in danger, orders to protect them are forwarded to the railroad men in that district. When such orders are received, the men sally forth to protect the freight and to battle with the adverse weather conditions and so in the final analysis we see that the efficiency of the railroads in their struggle against the weather elements depends not only upon their wonderful equipment and roadbed but also upon the loyalty and cooperation of their employees whom we term "the railroad men."

CONCLUSIONS.

From the above discussion we can draw many interesting and helpful conclusions. First of all, we see that railroading the world over involves the waging of a constant and costly battle against the weather elements. Of these elements, temperature, precipitation, and wind have particularly destructive effects upon roadbed and rolling stock. To overcome these effects we find that railroads have to spend large sums of money not only for equipment to carry on the battle but also for materials to repair the damages to the shattered battle-ground. As these expenditures amount to millions of dollars annually, it can be seen that the railroads pay dearly for their victory—yet a victory which means much to the life of the world.

We also note that our present complex civilization demands of the railroads certain special equipment by means of which perishable foodstuffs can be brought in a safe manner from distant producing regions to the great centers of consumption. This also involves the expenditure of millions of dollars which we may term as the cost of armor plate used in the protection of perishable goods against that all-important weather element, temperature.

And yet in spite of these terrible costs the battle goes on; no truce has ever been declared or ever will be, for fate has decreed the battle of the railroads with nature a perpetual one.

[29] *U. S. D. A. Farmer's Bulletin 1091*, p. 3.
[30] The Traffic Library, *Special Freight Services*, pt. 3, p. 119.

MONTHLY MEAN TEMPERATURES AT AREQUIPA, PERU.

By ALFRED J. HENRY, Meteorologist.

[Weather Bureau, Washington, May 3, 1921.]

The record of monthly mean temperature made at Arequipa, Peru, under the direction of Harvard College Observatory, Prof. Solon I. Bailey, Acting Director, are of very considerable interest to students of temperature distribution. Any one who has worked over the problem especially, as regards the Southern Hemisphere, is at once struck with the wide meshes of the network of reliable temperature observing stations in that hemisphere.

Through the courtesy of Prof. Bailey, the Weather Bureau has been supplied with a manuscript copy of the records of temperature as observed at Arequipa for the period 1896–1919, thus supplementing the published record which concludes with 1896. Arctowski[1] has published monthly means for Arequipa computed by the formula $\frac{1}{4}(8_a+2_p+8_p+8_p)$, for the years 1900–1910, both inclusive. When the attempt was made to bring this record down to date, it was discovered that the observing hours had been changed at the close of 1911, from 8 a. m., 2 and 8 p. m. to 10 a. m., and 10 p. m. Since it was not easy to obtain a correction that would enable us to combine the two series, it was determined to compute new monthly means from the daily extremes (max. + min. ÷ 2),[2] which were available for the entire period of observations, save only the 12 months, April, 1909–March, 1910, for which the record of minimum temperature is missing. In order to fill this gap, the means of the $(8_a+2_p+8_p+8_p)$ 4, as given by Arctowski[3] were corrected by adding 1° F. to the means for the months May to July, it having been shown that the means computed from the daily extremes for these months averaged about 1° higher than those computed from the 8 a. m., 2 and 8 p. m. observations. For the remaining months the monthly means computed from the two separate methods agreed within a small fraction of a degree Fahrenheit.

The Arequipa record was discussed in a paper by the writer in the Febraury, 1921, REVIEW,[4] and it was there pointed out that the variations in the annual means at that place synchronized very well with those of Habana and indeed other far distant points.

It is interesting to note that the synchronism existing especially between Arequipa and Habana prior to 1910 also continues to 1912, both stations showing a very well marked maximum in that year. Thereafter, however, the two curves diverge very widely. Arequipa reaching a second maximum in 1915, a decided minimum in 1916–17 and a third maximum in the summer of 1918–19; the last named was the greatest heat maximum experienced during the period of observations. It will be interesting to note whether these two heat maxima at Arequipa and the decided minimum of 1916–17 were experienced at other points in the Southern Hemisphere. It may be remembered that severe cold was experienced in the Northern Hemisphere during the winter of 1917–18, about 6 months later than in the Southern Hemisphere.

The complete table follows:

Monthly mean temperature (max. + min. ÷ 2), at Arequipa, Peru (°F.)

[Latitude, 16° 24′ S.; longitude, 79° 46′ W.; elevation, 8,040 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1888											60.8	60.2	
1889	62.2	62.2	59.5	58.3	55.6	54.1	53.5	53.6	56.3	54.6	55.4	55.4	56.7
1890	58.6	57.3	57.2	55.6	53.8	51.2							
1891													
1892	58.4	58.1	58.4	57.8	56.6	57.4	57.4	56.5	58.2	57.2	55.8	58.0	57.5
1893	56.0	57.7	56.4	56.8	55.3	54.4	55.8	55.8	57.6	57.6	56.4	57.6	56.4
1894	57.4	58.3	57.1	57.0	57.2	57.6	57.2	57.6	58.0	57.1	58.0	57.8	57.5
1895	58.0	57.6	57.3	57.5	57.5	58.8	58.2	57.8	59.3	58.0	58.2	59.3	58.1
1896	58.2	59.4	58.0	59.4	58.4	58.2	58.2	59.0	57.8	59.0	58.0	59.2	58.6
1897	60.1	60.0	58.6	58.7	57.4	57.4	57.2	58.0	59.4	58.7	58.6	58.0	58.5
1898	58.0	55.9	57.4	58.0	58.1	57.0	57.1	55.6	58.1	57.6	57.2	57.5	57.3
1899	57.2	56.8	57.2	58.4	58.6	57.1	56.6	57.7	60.6	58.1	58.4	59.4	58.0
1900	59.2	60.1	60.8	60.0	58.6	58.6	57.0	58.6	59.1	59.0	59.2	59.4	59.1
1901	58.3	59.6	58.3	58.9	59.4	57.7	57.2	59.0	59.2	58.8	57.6	58.2	58.5
1902	58.2	58.2	58.2	58.7	59.4	57.2	59.0	58.0	59.2	58.4	58.8	59.4	58.6
1903	59.6	61.4	58.6	57.2	57.2	56.4	57.1	56.6	58.6	57.4	56.4	56.0	57.7
1904	56.6	56.6	56.5	57.0	56.6	54.4	56.8	57.8	57.9	57.4	58.4	58.2	57.0
1905	58.2	59.5	57.1	58.2	58.7	58.9	58.2	57.7	58.0	59.0	58.4	57.8	58.3
1906	58.7	59.0	58.4	59.0	58.2	56.1	57.0	57.2	58.8	56.8	58.4	56.5	57.8
1907	57.6	56.2	58.8	57.0	58.1	57.4	56.6	57.4	58.6	57.8	58.2	59.0	57.7
1908	59.0	57.8	58.4	58.4	58.9	58.4	56.4	56.4	57.4	56.2	57.0	57.5	57.6
1909	57.4	57.0	58.4	56.7	55.7	55.1	56.8	56.2	58.7	58.0	57.3	57.5	57.1
1910	55.8	56.1	55.2	58.6	57.2	57.8	56.6	57.3	58.1	57.2	58.6	57.6	57.2
1911	57.2	59.3	56.2	58.9	58.0	57.1	58.0	58.1	59.4	59.2	58.6	60.3	58.4
1912	61.1	60.0	60.3	59.4	59.5	58.4	56.9	58.0	58.2	57.7	56.4	58.2	58.7
1913	58.4	58.7	58.2	57.2	57.2	56.8	58.3	57.0	57.2	58.1	58.8	59.3	57.9
1914	58.7	60.2	59.4	58.5	59.8	58.4	57.9	58.6	58.2	57.2	57.6	60.0	58.7
1915	60.8	60.0	61.7	61.4	61.2	57.9	57.6	58.4	58.2	58.6	57.5	58.8	59.3
1916	58.7	57.2	57.4	57.2	57.6	55.4	54.8	55.7	58.2	57.2	55.1	56.5	56.7
1917	56.4	54.8	57.6	56.5	55.9	55.8	56.1	57.3	56.4	57.2	57.0	55.6	56.4
1918	57.0	58.2	56.7	56.8	58.2	58.2	58.4	59.0	58.4	58.6	61.2	63.7	58.7
1919	61.1	61.4	60.6	59.4	59.2	59.2	58.1	58.7	59.1	60.0	58.6	58.8	59.5
1920	58.7	58.1	58.2	59.6	57.7	58.0	58.9	57.6	58.3	58.1	58.1	59.2	58.4
Means	58.4	58.5	58.1	58.1	57.8	57.0	57.0	57.4	58.4	57.9	57.9	58.4	57.9

[1] *Bulletin American Geographical Society*, 44: 599.
[2] In this connection, see C. E. P. Brooks: True mean temperature, MO. WEATHER REV., April, 1921, p. 226.
[3] *Loc. cit.*
[4] Pages 62–70.

CLIMATE AND HEALTH IN THE SOUTH AMERICAN TROPICS.[1]

By FREDERICK L. HOFFMAN.

[Prudential Insurance Co., Newark, N. J., Feb. 6, 1922.]

I can only very briefly give expression to my views concerning the climatic conditions of northern South America in their relation to health and mortality. The general public is accustomed to regard the Tropics as having an unhealthy "climate," without a clear grasp of what the term climate really implies. Writers on tropical explorations make much of heat and humidity without clearly emphasizing the conditions under which disagreeable experiences were had. Wholly false impressions prevail regarding the so-called climate of the immense Amazonian Basin, as to which, as yet, few instrumental observations exist, while most of the conclusions of even scientific observers are little less than vague generalizations. Hence much if not most of what has been written on the tropical climate of northern South America is seriously misleading and a deterrent to the settlement of a vast region which is one of enormous economic possibilities for the future.

There are no reasons whatever why a so-called tropical climate should be *per se* an unhealthy one. Tropical heat, of course, gives rise to tropical parasitical life with its resulting evil pathogenic effects upon the human organism. But such diseases as result indirectly from tropical heat and moisture can now be effectively guarded against by the intelligent observance of ordinary rules of living. Northern climates require safeguarding against extreme cold, while southern climates rarely require safeguarding against extreme heat. It is true that the climate is warm throughout the larger portion of the year, but the warmth is usually limited to the daytime, while the nights are cool and often distressingly so. The chief casues of ill health and premature death in northern South America are not tropical diseases but respiratory and rheumatic affections, which prevail to an enormous extent among the native population. The sensible temperature at night is at times extremely trying and guarded against only by an abundance of covering, which is usually wanting in the case of the native population. Houses are poorly constructed and the draughts during the night chill the body to a point where disease resistance reaches its lowest ebb. Coughs and colds are of practically universal occurrence and no precautions are employed on the part of the natives, who are improperly fed, improperly clothed, and improperly housed. The resulting high mortality is not chargeable to the climate, but to apathy and indifference and colossal ignorance.

It is regrettable that there should be such a paucity of instrumental observations, particularly for the nighttime. The admirable climatological records of the Madeira-Mamore Railway, for illustration, are only for the daytime and limited to four readings, respectively, at 6:30 a. m., 11 a. m., 3 p. m., and 6:30 p. m. But in my own experience the most trying period is between 2 and 3 o'clock in the morning, when the temperature may be 30° lower, and even more, than in the daytime. The instrumental records of the Madeira-Mamore Railway, as provided by the Engineering Department, are, however, of great value in that they extend over the entire period of construction from 1907 to the present day. It is to be hoped that this material will sometime be made available to students of the South American climate, while at the same time expression may be given to the hope that the records may be extended to include automatic observations during the night. While it is always warm during the day, it is rarely excessively hot. In my analysis of the tropical mortality of northern South America I failed to meet with a single case of sunstroke or thermic fever. Such cases occur, but generally in the remote sections and among men indifferent to weather conditions and employed at possibly exhausting toil. Personally, I never suffered the slightest inconvenience from high temperatures, while, as I have said before, I suffered distressing results of low temperatures during the night.

There are likewise widespread erroneous views concerning the humidity, which, in settled localities, is far from being as serious a detriment to health and comfort as is generally assumed to be the case. In the forest, of course, the humidity is high, and in the morning clothing, etc., will be found thoroughly saturated unless protected by adequate rubber covering, but in settled sections, like Porto Velho, Riberalta, or Manáos, the humidity is of quite secondary sanitary importance. As I have shown in my report to the English-Speaking Conference on Infant Welfare at London, England, on the climatic conditions of York and Homestead, Pa., with reference to infant mortality, the death rate from diarrheal diseases reaches excessive proportions when a high humidity coincides with a high temperature.[2] It should not be difficult to determine the precise point of danger, which, if known, could be effectively guarded against as one of the most important steps toward the saving of infant life. Likewise tropical climates can be guarded against by rational adaptation to local conditions, and I may conclude by saying that in my own case during seven months I never suffered an hour of serious illness from any cause whatsoever.

It would be interesting to have careful instrumental observations made on daily weather changes in the Tropics and their physiological effects on bodily conditions. One certainly feels the changes from warmth to cold much more in the Tropics than in the north, and changing in my own case from Para with a temperature of 80° to Toronto with a temperature near to zero, I can not but feel that such changes when properly safeguarded against are of very slight, if any, importance in their bearing upon health and longevity.

I regret that my own instrumental observations were materially interfered with by unsuitable or defective instruments, breakage, etc., as well as inexperience. But I feel strongly, as a result of my investigations, that the difficulties in the Tropics as regards health are not essentially climatic, but concerned with food, clothing, housing, and habits, all of which are subject to intelligent and rational human control. In brief, in the light of my experience I can not but feel that the climate of northern South America has been grossly maligned by those who, in a spirit of reckless adventure, disregarded known safety precautions, while on the contrary white residents observing accepted principles of personal hygiene enjoy good health and suffer in but a minimum degree from the so-called tropical diseases.

[1] Presented before American Meteorological Society, Toronto, Canada, Dec. 29, 1921.

[2] *New York Medical Journal*, Feb. 1, 1922.

DEATH VALLEY—THE HOTTEST KNOWN REGION.

By ANDREW H. PALMER, Meteorologist.

[Weather Bureau, San Francisco, Calif., January, 1922.]

SYNOPSIS.

Ten years of record obtained at the United States Weather Bureau's substation at Greenland Ranch, in Death Valley, Calif., indicate that this is the hottest region in the United States, and, so far as extreme maximum temperatures are concerned, the hottest known region on earth. The temperature of 134° F., recorded on July 10, 1913, is believed by meteorologists to be the highest natural air temperature ever recorded with a tested standard thermometer exposed in the shade under approved conditions. High temperatures are common throughout the year, but the highest occur during midsummer. Precipitation is extremely light, the normal annual precipitation being less than 2 inches. Evaporation is excessive, as the relative humidity is extremely low most of the time, and especially during the hot spells of summer. White people find the midsummer heat most trying; even the Indians go up to the Panamint Range during July and August. The weather station maintained at Greenland Ranch in cooperation with the Pacific Coast Borax Co. is unique in many ways.

Desert regions of the United States.—Textbooks in geography used in the public schools a generation ago contained maps on which the legend "Great American Desert" covered all the region between the Missouri River and the Sierra Nevada-Cascade Mountain Range. As a matter of fact, the only true and extensive desert regions of the United States lie in southeastern California, southern Nevada, and western Arizona. They embrace an area of about 570,000 square miles. Among the most conspicuous and typical wastes are the Colorado Desert, the Mojave Desert, and Death Valley, all of which are in California.

Contrary to a very general impression, the desert regions of the United States are not all level wastes of sand. Included within these regions are lofty mountain ranges, deep and gloomy canyons, sand hills, pinnacles, "needles," level plains stretching to the horizon, and depressions many feet below sea level. Throughout these regions the characteristic feature is little or no rainfall. Consequently there are no streams, except a few like the Colorado River, which has its origin in mountain snows hundreds of miles away. There are no lakes, except one or two like Owens Lake, a shallow body of salt water which is rapidly evaporating. Dry lake beds indicate that water may once have been more abundant in these regions than it is now.

Death Valley.—Death Valley is situated in southeastern California, near the Nevada boundary. It extends from north to south through a distance of about 100 miles, and lies between high mountain ranges. The width varies from 2 to 8 miles. It is the deepest depression in the United States, though only about 100 miles southeast of Mount Whitney, elevation 14,501 feet, the highest point in the United States. The lowest point of Death Valley is not definitely known—one estimate places it at 280 feet, and another at 337 feet below sea level. Its sides rise precipitously from the valley floor, which is generally level. The center of the valley is about 260 miles by road from Los Angeles.

Historically, Death Valley has been intimately related to the pioneer events of the West. This is due to the fact that adventurous pioneers sometimes used it as a means of entry into California when they came overland from the East, before the days of the railroads. But these early adventurers were unacquainted with such regions, and disasters were frequent as a result.

Greenland Ranch.—Until recently the only permanent inhabitants of Death Valley were a few of the Piute, Shoshone, and Mojave Indian tribes, whose day of total extermination is near. The first permanent white settlement was established about 40 years ago by the Pacific Coast Borax Co., of 20-mule team fame. A tract of about 65 acres situated on the eastern edge of Death Valley was placed under irrigation. The water supply was a difficult problem to solve, in view of the fact that the normal annual precipitation is less than 2 inches. Not infrequently less than 1 inch of rain falls in a year. Successful agriculture can not be maintained on less than 15 or 20 inches of precipitation annually without the aid of irrigation. A group of springs known as Warm Springs was found in the Funeral Mountains near by, and these serve as the source of irrigation water supply;

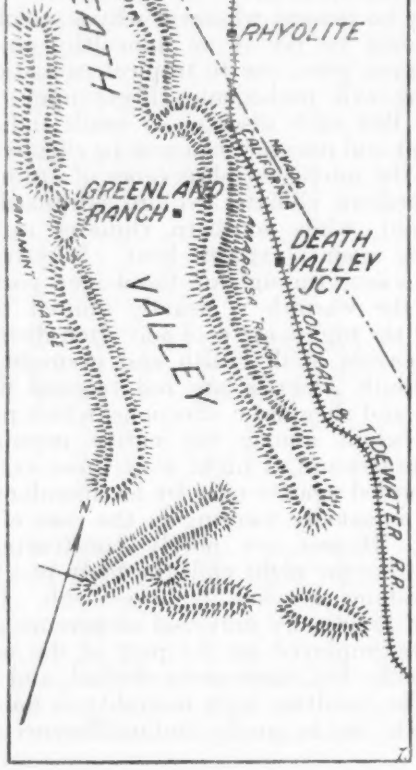

FIG. 3.—Map of Death Valley, Calif.

the temperature of the water issuing from these springs is about 100° F.

This ranch was originally called Furnace Creek Ranch, because it was situated near a depression where the air suggested a blast from a heated furnace. In the latter depression water may be found throughout the year in what is known as Furnace Creek, which is fed by about 100 springs. The flow of water is about 80 miner's inches (2 c. f. s.), a quantity sufficient to irrigate 70 acres.

After the ranch was successfully established its name was changed to Greenland Ranch because of the marked contract between the green alfalfa fields and the eternally brown desert surrounding. Four crops of alfalfa are gathered each year. The principal product of the ranch is dressed meat; however, experiments are being made in

(To face p. 10.)

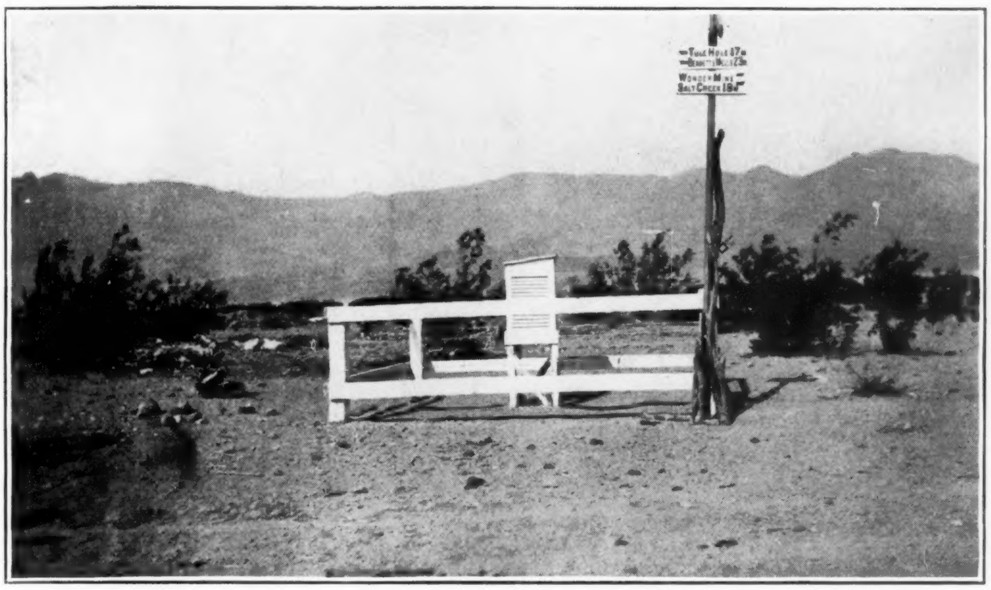

FIG. 1.—U. S. Weather Bureau instrument shelter at Greenland Ranch, Death Valley, Calif., 178 feet below sea level.

FIG. 2.—Cutting alfalfa on Greenland Ranch in April.

raising poultry, and in growing vegetables, dates, citrus and deciduous fruits. The ranch was established and is maintained for the purpose of serving as the source of food supply to miners at work in the adjacent mountains.

Death Valley is perhaps the most maligned natural attraction in North America. For the winter automobile tourist its scenic possibilities are vast. This famous or infamous valley is almost as brilliantly colored as is the Grand Canyon of the Colorado.

The Automobile Club of southern California is erecting 1,200 metal-enameled signs on the desert roads and 250 signs of waterholes. The California State legislature recently appropriated $5,000 for the installation of signs indicating the positions of springs and waterholes in the desert portions of the State. In 1916 Congress authorized the Secretary of the Interior "to discover, develop, protect and render more accessible for the benefit of the general public, springs, streams and waterholes on desert and public lands of the United States and in connection therewith to erect and maintain suitable and durable monuments and signboards at proper places and intervals along and near the accustomed lines of travel and over the general area of said desert lands, containing information and directions as to the location and nature of said springs, streams and waterholes, to the end that the same may be readily traced and found; also to provide convenient and ready means, apparatus and appliances by which water may be brought to the earth's surface at said waterholes for the use of such persons; also to prepare and distribute suitable maps, reports and general information relative to said springs and waterholes and their specific location."

In 1911 the United States Weather Bureau established a weather station on Greenland Ranch in cooperation with the company which operates the ranch. Carefully tested maximum and minimum thermometers together with a standard 8-inch rain-gage and a regulation instrument shelter were lent by the Weather Bureau and were installed under approved conditions. The white foreman of the ranch was appointed cooperative observer.

More than 10 years of unbroken weather records at this unique station are now on file. They are among the most interesting weather records in existence. The following are some of the noteworthy features:

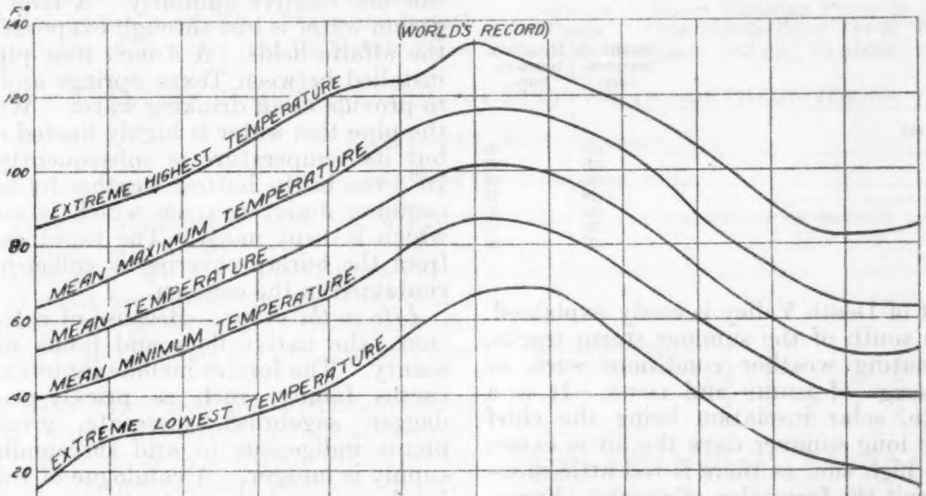

FIG. 4.—Average and extreme temperatures recorded at Greenland Ranch.

High temperatures.—Nearly every summer during the past few years the highest natural air temperatures recorded in the United States by means of tested thermometers under approved methods of exposure have been those for Greenland Ranch. The following is a list of the extreme maximum temperatures recorded at this station during the past 11 summers:

TABLE 1.—*Extreme maximum temperatures recorded at Greenland Ranch.*

	°F.		°F.
1911	122	1917	125
1912	120	1918	125
1913	134	1919	123
1914	126	1920	125
1915	124	1921	123
1916	127		

The extreme maximum temperature of 134° recorded on July 10, 1913, is the highest natural-air temperature ever recorded on the earth's surface by means of a tested standard thermometer exposed in a standard ventilated instrument shelter. By way of explanation it should be stated that the instrument shelter used at this station is the same as those used at several thousand other weather stations maintained by the Weather Bureau throughout the United States. It has louvered sides, a double roof, tight floor, is painted white, faces north, and its floor is about 4 feet from the ground. It is about 50 feet distant from the nearest high object. There is a free circulation of the air through the louvered sides, the double roof cuts off the heating effect of the sunshine, and the tight floor shuts out reflected and radiated heat from the ground.

There is no authoritative and reliable weather record in existence which contains a higher natural-air temperature than the one here recorded on July 10, 1913, namely, 134°. In the *Encyclopedia Britannica* (9th ed., vol. 30, p. 810) it is stated that a temperature of 167° was recorded in the Desert of Gobi, in Mongolia. This unbelievable temperature has never been accepted by meteorologists as a trustworthy record, however.

At Greenland Ranch, temperatures of 100° or higher occur almost daily during June, July, and August. The hottest month on record is that of July, 1917, when the mean temperature was 107.2°.

TABLE 2.—*Temperature data, Greenland Ranch, Death Valley, California, 1911–1921.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Mean temperature	52.5	58.1	65.4	74.2	81.7	94.2	101.2	99.0	89.2	74.1	60.3	51.5	75.0
Mean maximum temperature	63.8	71.1	79.6	89.0	97.1	110.5	115.7	114.0	105.2	87.9	74.2	64.3	89.4
Mean minimum temperature	39.6	45.0	51.2	59.3	66.3	78.0	86.6	84.0	73.3	60.3	48.2	39.6	61.0
Extreme highest temperature	85	91	98	109	120	124	134	126	118	106	91	82	134
Extreme lowest temperature	15	28	30	35	42	55	67	68	54	40	27	21	15

A hot spell which has perhaps not been equaled anywhere else on the earth's surface, so far as reliable weather records are available, is the following, as recorded at Greenland Ranch:

TABLE 3.—*Temperatures at Greenland Ranch during hot spell of July, 1913.*

	Maximum temperature.	Minimum temperature.
1913	°	°
July 8	128	90
9	129	93
10	134	85
11	129	85
12	130	85
13	131	85
14	127	86

The excessive heat of Death Valley is easily explained. Situated well to the south of the summer storm tracks, there are no alternating weather conditions such as characterize the passage of HIGHS and LOWS. It is a typical solar climate, solar insolation being the chief control. During the long summer days the air is excessively heated by the high sun, as there is too little moisture in the air to permit the formation of clouds. Excessive heating causes ascending currents, and air slips down the sides of the adjacent mountains to take the place of air rising over the valley floor. The air which slips down the mountain slopes is heated dynamically as it descends. The winds are local and convectional. The desert sand, gravel, rocks, and salt are so highly heated during the long days that they do not have opportunity to cool through radiation during the short nights. The cumulative effects of these various agencies result in the temperatures quoted.

Rainfall and humidity.—The precipitation record during the past 10 years at Greenland Ranch is not less interesting than the temperature record. Not infrequently six consecutive months have passed without measurable rain. During 1917 the total rainfall was less than one-half inch. During 1919 it was slightly over one-half inch. The average annual precipitation is less than 2 inches. However, "it never rains but it pours." Rainfall is usually of short duration, but it rains hard when it rains. Snowfall of measurable depth is unknown. Gales and dust storms are of frequent occurrence. There are few days when the sun does not shine. In fact, there is some sunshine practically every day in the year.

TABLE 4.—*Precipitation at Greenland Ranch, Death Valley, 1911–1921 (inches).*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1911	.....	.....	.....	.....	.....	0	0	0	1.40	0	0	0	.....
1912	0	0	1.10	T.	T.	0	0.10	0	0	0.20	0	0	1.40
1913	0.01	1.90	.10	0	0.01	0	.60	0.01	.30	0	1.61	0	4.54
1914	.67	.21	0	.12	0	0.05	0	0	0	0	0	0.60	1.65
1915	1.10	.02	.02	.08	.02	0	.07	0	0	0	0	0	1.31
1916	1.51	.20	.02	0	.40	0	0	0	0	.10	0	0	2.23
1917	.04	0	0	.01	.30	0	.06	0	.01	0	0	0	.43
1918	0	.30	.75	.05	T.	0	0	.01	0	.01	0	0	1.12
1919	0	0	.01	0	0	0	.01	0	0	0	.20	.30	.52
1920	.60	1.00	.30	0	.10	.60	0	.10	0	.20	0	0	2.90
1921	.40	0	0	0	0	0	0	0	0	.....	.....	.....	.....
Mean	.43	.36	.23	.03	.08	.06	.08	.01	.16	.05	.18	.09	1.79

T. means trace.

Though no long-continued records of humidity have been kept, occasional determinations show that during the hot summer months the relative humidity may fall as low as 5 per cent. Many curious facts result from this low relative humidity. A large portion of the irrigation water is lost through evaporation before it reaches the alfalfa fields. A 4-inch iron pipe 1 mile long was installed between Texas Springs and the ranch in order to provide clean drinking water. While passing through the pipe this water is highly heated during the daytime, but its temperature is subsequently reduced to about 70° even in the hottest weather by being confined in the common desert canteen which is covered with burlap, which is kept moist. The rapid evaporation of water from the burlap covering is sufficient to cool the water contained in the canteen.

Life in the desert.—Because of extreme climatic conditions, the native flora and fauna of Death Valley are scanty. The former include innumerable varieties of the cactus family, such as prickly-pear, cholla, Spanish dagger, sagebrush, mesquite, greasewood, and other plants indigenous to arid surroundings where a water supply is meager. A catalogue of the fauna is almost as brief, and includes only the jack-rabbit, horned toad, scorpion, lizard, rattlesnake, kangaroo cat, desert turtle, fox, mountain sheep, badger, lynx, and other wildcats. Birds of many varieties are numerous, as migrating flocks often stop at the ranch for food and drink, as well as to rest. The common insects are abundant. The dry desert has been an impenetrable barrier to the natural migration of various plants. However, within the past few years Bermuda grass, "devil grass," and Johnson grass have secured an entry, and now give trouble as in other regions.

Not being accustomed to persistent high temperatures and moistureless air, white men do not remain long in Death Valley. While sunstroke is unknown there, several people have perished from heat, thirst, or exhaustion. During summer most of the work is done at dawn or shortly after sunset, as the blazing sun renders work in the middle of the day impracticable, and even dangerous. Mr. O. A. Denton, the white foreman who remained longest, namely, eight years, was a mechanical genius in providing a semblance of comfort in hot weather. During the summer he made his bed in front of a revolving fan, after wetting his blanket and after sprinkling the floor with water. The fan was driven by an overshot water wheel.

Like the St. Bernard hospice in the high Alps of Switzerland, Greenland Ranch also serves as a traveler's relief station. The immense barren tracts of the Southwest have no natural oases similar to those of the Great Sahara of Africa. However, they contain, separated by long distances one from the other, small springs and waterholes which lie concealed by surrounding scant bushgrowth, reedy vegetation, and quiete or desert grass. The chief evidences of human occupation are the long, long roads which lead from one watering place to another. Greenland Ranch has saved the life of many a lost traveler or prospector who has staggered within its borders with parched throat and speechless swollen tongue. At the rear of the ranch there are four mounds—graves of those who have perished of thirst or heat before they were able to reach the ranch.

Blessed with abundant precipitation, residents of the eastern United States little appreciate the value of water. Until one has seen the desert portions of the Southwest he can not fully understand the significance of generous rainfall. In the West water is wealth. With the aid of irrigation, desert portions of Arizona and California have been made "to blossom as the rose." Marvellous transformations have been enacted in the Imperial Valley of California, and in the Salt River Valley of Arizona. But because of excessive heat and the salt and alkali in the soil it would be a much greater miracle to transform Death Valley into an agricultural region.

The writer is indebted to Maj. J. Boyd and Mr. O. A. Denton for valuable suggestions in the preparation of this article, and for most of the illustrations which accompany it.

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WEATHER RECORDS AT LOOKOUT STATIONS IN NORTHERN IDAHO.

By J. A. LARSEN, Forest Examiner.

[Priest River Forest Experiment Station, 1920.]

Records which furnish information regarding weather conditions on mountains have always been of interest to the public and to scientists. To the United States Forest Service these are of great use in constructing the ground work for better forest fire protection. Students of climate, botany, ecology, and animal life are always eager for such data.

The tables given below have been prepared from records of air temperature, relative humidity, and air movement at Forest Service fire lookouts in northern Idaho during the summer of 1919. The instruments used are standard maximum and minimum thermometers of the United States Weather Bureau pattern, the Robinson anemometers and sling psychrometers. The thermometer shelters were improvised from wooden boxes placed at regular height above the ground and oriented so that the instruments were shaded from the sun at all times. The instruments at the Experiment Station lookout were housed in a regular Weather Bureau shelter. The data for the lower stations with which the mountain records are compared are supplied by the United States Weather Bureau cooperative stations at Wallace, Kooskia, Spokane, and Priest River Forest Experiment Station.

The lookout points at which these records were taken are as follows:

Lookout.	National forest.	Elevation (feet above sea).	Observer.
Coolwater	Selway	6,930	Gerald Gill.
Monumental Buttes	St. Joe	6,979	Eugene Harpole.
Sunset	Coeur d'Alene	6,424	Paul Wickward.
Mount Silcox	Cabinet	6,840	Louis F. Rosenthal.
Experiment Station	Kaniksu	6,000	G. W. Simmons.

The figures in Tables 1 and 2 represent fairly well the average air temperature conditions in northern Idaho during the warm and clear days which usually occur from the beginning of July until the middle of September.

TABLE 1.—*Air temperature on lookouts and at low stations, summer, 1919 (° F.).*

Lookouts and cooperative stations.	July.			August.			September.			Dates missing.
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	
Coolwater, elevation 6,930.	71.1	51.1	61.0	69.4	51.8	60.8	62.1	42.2	52.1	Sept. 21-30.
Kooskia, elevation 1,261.	92.8	50.1	71.4	86.2	51.3	68.8	71.9	40.8	56.4	
Monumental Buttes, elevation 6,979.	71.3	47.2	59.2	72.6	49.1	60.8	59.9	39.5	49.7	Sept. 18-30.
Wallace, elevation 2,770.	85.9	48.5	67.2	83.3	42.5	66.3	71.1	35.6	53.4	
Priest River Experiment Station lookout, elevation 6,000.	69.3	51.9	60.6	68.6	51.0	59.8	57.3	41.6	49.9	Aug. 5-12.
Priest River Experiment Station, elevation 2,300.	86.1	42.3	64.2	84.8	47.8	62.9	72.0	41.1	56.5	Sept. 20-30.

TABLE 2.—*Diurnal march of air temperature on the mountain and at the valley station, August, 1919 (° F.).*

Location and elevation.	A. M.						P. M.					
	2	4	6	8	10	Noon 12	2	4	6	8	10	12
Valley, 2,300	42.7	40.4	39.5	50.4	64.5	76.7	82.4	83.3	78.5	61.2	51.0	46.1
Mountain, 6,000	54.4	52.8	54.6	59.2	61.3	64.3	67.2	65.7	61.2	57.7	56.5	55.3

The data in Table 1 show that the maximum air temperatures are in every instance higher at the low than at the high stations; the differences vary from 10° to 17° and in one case is as great as 21°. The minimum temperatures are in every case lower in the valleys than on the mountains, but the differences are not as pronounced as in case of the maxima; they vary in most cases 2, 3 and 4° and are not above 10°. These inversions are no doubt due to the rise of the heated air from the valley land at night to higher levels and a simultaneous downward flow of cold air along the

gulches and draws which settles over the low land. Naturally the greater horizontal air circulation on the mountains both day and night brought out in Table 4 is also influential in equalizing the air temperature on the mountains.

Data on wind velocity for low stations are available for Spokane and Priest River Experiment Station. These are compared with air movement on the mountains in Table 3.

TABLE 3.—*Wind movements on lookout stations, 1919 (except as otherwise noted).*

[Miles per hour.]

Station and elevation.	July.		August.		September.		Dates
	Average.	Maximum[1]	Average.	Maximum.	Average.	Maximum.	
Coolwater, elevation 6,930	8.2	12.7	8.1	10.2	9.9	16.2	Sept. 21-30.
Monumental Buttes, elevation 6,979	13.0	28.6	15.0	29.6	15.5	27.5	July 1-7. Sept. 18-30.
Sunset, elevation 6,424	9.6	15.9	10.2	14.9	12.6	21.5	
Mount Silcox, elevation 6,840:							
1917	13.0	18.8	11.5	23.1	12.4	21.6	July 1-12. Sept. 20-30.
1918	12.7	26.7	20.0	38.0	14.3	31.0	Sept. 24-30.
Priest River, Experiment Station, elevation 6,000	9.5	16.1	8.9	14.3	10.6	22.4	Aug. 5-12. Sept. 20-30.
Priest River, Experiment Station, elevation 2,300	3.5	5.6	3.1	4.7	2.8	4.4	
Spokane, Wash., elevation 1,943	5.9	27.0	5.6	28.0	5.3	30.0	

[1] The highest for any one whole day.

The average daily wind velocities at the mountain stations are from two to three times that shown by the low stations and the maximum daily movement at Priest River Experiment Station conforms to this relation, but at Spokane the maxima are as great as those on the mountains. The explanation for this is most likely due to the fact that at the Experiment Station in northern Idaho the wind is obstructed to some extent by the north and south trend of the mountains, but at Spokane the wind from all directions is less obstructed.

Comparative wind movement for different parts of the day for high and low stations are given in Table 4. On the mountain there is very little difference in movement by night and by day—only a slight increase in the afternoon—but in the valley the air is almost still at night and shows the maximum movement in the afternoon.

For comparison of the relative humidity at high and low stations it is necessary to have simultaneous observations. These are not always easy to obtain. Such records were taken at Priest River Experiment Station for 1917 and given in Table 4.

In keeping with the air-temperature relations at high and low stations shown in Table 1 the relative humidity on the mountain is lower at night and greater during the day than at the low station. In August the air at 8 a. m. in the valley showed 13 per cent greater relative moisture than on the mountain; at 1 p. m. the valley air was already 23 per cent and at 5 p. m. 14 per cent drier than on the mountain. These relations naturally depend upon the weather conditions; during rainy, cloudy, or windy weather the differences in temperature, wind, and humidity are less pronounced than in clear weather.

TABLE 4.—*Diurnal changes in wind movement and relative humidity on the mountain and in the valley, Priest River Experiment Station, summer, 1917.*

Time of observation.	Location and elevation.	July.		August.		September.	
		Wind (miles per hour).	Relative humidity.	Wind (miles per hour).	Relative humidity.	Wind (miles per hour).	Relative humidity.
			Per cent.		*Per cent.*		*Per cent.*
8 a. m.	Mountain 6,000	[1] 10.9	75	8.4	60	8.1	71
8 a. m.	Valley 2,300	[1] 0.9	66	0.8	73	0.8	87
1 p. m.	Mountain	9.9	70	7.9	49	8.0	62
	Valley	3.6	32	3.1	26	2.5	47
5 p. m.	Mountain	11.4	65	9.7	46	7.3	56
	Valley	3.9	34	3.2	32	2.3	57

[1] Average movement between the hours of observation.

It is assumed that the extent or degree to which these variations take place will depend somewhat upon the general relation of mountains to plains or bodies of water and whether the land is barren or forested, and the position of the stations in relation to wind gaps or principal divides, but the data do not admit of such comparisons.

From a standpoint of forest fires these differences in weather condition at high and low stations in summer explain why the fires burn better at higher than at lower elevations at night. The greater air movement fans the flames, supplies more oxygen, and the higher temperatures keeps the relative humidity lower so that there is less atmospheric moisture to dampen the dead needles and moss. The high-air temperature and low humidity at lower elevations during the afternoons produce more critical conditions than prevail on the mountains at this time of the day.

The mountain vegetation in this region probably works more energetically than that on the flats and at lower points, not only because of the longer hours of sunshine per day on the mountain but also because of the more moderate temperatures at night. The greater transpiration which takes place at higher elevations on account of decreased atmospheric pressure and increased wind must be somewhat counterbalanced by the higher relative humidity which prevails on the mountain during the day.

The vegetation on the lower slopes and flats is more exposed to injury by frost at night and to severe draft by day than that on the mountain, but fortunately the air movement at the lower elevations in the afternoon is only about one-third as great as that on the mountain.

GREAT FLOODS IN THE OHIO 160 YEARS AGO.

By HENRY PENNYWITT, Meteorologist.

[Weather Bureau, Pittsburgh, Pa., Dec. 15, 1922.]

The library of Mrs. Mary Darlington, of this city, contains an account of a great flood in the rivers at Pittsburgh, on January 9–11, 1762. The account is found in a letter of Col. Henry Bouquet, commander of Fort Pitt, to Gen. Amherst, commander in chief at New York, dated January 12, 1762. The letter follows:

FORT PITT, *January 12, 1762*.

To GEN. AMHERST,
Commander in Chief, New York.

SIR: I have to inform your excellency of the great damage this fort sustained by an extraordinary flood the 9th instant. We had snow almost every day in December, and from the beginning of this month clear and cold weather. Both rivers were low and clear of ice. The 8th we had a rain that continued that night and next day with a universal thaw. The 9th the rivers were 10 feet over the banks, which had not happened in any flood since this place was built. The water came upon us through the drains, gate and sally ports, and boiled out of the ground in several parts of the area.

I had the battoes brought into the fort, loaded them with provisions, and as we had 4 feet of water in the area and 9 in the casements I sent part of the garrison which could be of no further service, to the upper town upon rising ground, and kept only so many in the fort as I could carry off in the battoes should we be reduced to that extremity.

The two rivers, entirely covered with ice and trees, had joined above the fort, but the most rapid current continued on each side. We remained in that situation till 1 o'clock in the morning, when we were unexpectedly relieved by a sudden frost. The water was then upon a level with the top of the rampart at the NW. side, where there is no parapet, and did not begin to fall till the next day at 10 o'clock.

The 11th we could discover part of our disaster. All the sod work of last year and part of the year before tumbled down and a number of pickets washed away. The curtain on the Monongahela, finished two years ago, has suffered less, though part of the sod is gone. The part reset with brick does not appear much hurt except the parapets.

The long barracks built in 1759 for the Artillery and all the houses upon the bank of the Allegheny beyond the epaulement have been carried off, and several in the lower town. No lives have been lost, though most of the effects of the traders were, by the suddenness of the flood, though we gave them all the assistance in our power.

Common depth of the Allegheny at low water 4, 5, or 6 feet. Perpendicular height on the 9th, 39 or 41 feet. Rise in the flood 34 to 35 feet, which is 10 feet over the bank. I am, sir,

Your most obedient and humble servant,

(Sig.) H. BOUQUET, *Col.*

The account of the March, 1763, flood is contained in a letter from S. Ecuyer to Col. Boquet;[1] it follows:

FORT PITT, *March 11, 1763*.

To Col. BOUQUET.

SIR: I send you the returns of the past month, with an account of the inundation of this post. The 6th of March the two rivers being somewhat swollen, but with little ice, the 6th, 7th, and 8th great rain. The 7th in the morning the berme or turf of the flank of the bastion off the south and a part of the stone edging had fallen into the fosse. The river continuing to swell, I had the provisions removed from the ground floor and the various ammunitions; worked all day closing the drains, preparing everything against inundation as best I could. At 10 o'clock in the evening the two rivers united and the water around the fort increased 1 foot an hour. On the 8th at 2 o'clock p. m., the flats and boats had been drawn to the bridge. At 4 o'clock in the morning 6 inches of water in the fort and the Allegheny full of ice. Two hours after midday I detached 2 officers and 30 men to the upper town with 15 days provisions for all the garrison. At midnight I brought all the boats and flats into the fort and prepared to save all and abandon the place the following day, but happily on the 9th at 8 o'clock in the morning, the water was at its greatest height and at midday it fell 2 inches (the highest means 22 inches higher than last year).

All provisions and ammunitions are saved and in good condition. I have followed your plan as best I could. Here is an account of our losses. The shop of the blacksmith is entirely gone; the little wood gathered for the construction of the boats has followed several houses of the lower town; I believe our garden is lost by the fault of the sergeant, who did not inform me of the danger; all fences of the garden carried off by the ice; the poor deer has had its leg broken. We are occupied in repairing the little devastation in the interior of the fort. Tomson, the tanner, and Sheperd, the carpenter, are drowned, the first at Turtle Creek, and the other at Two Mile Run.

I have the honor to be your very humble and obedient servant,

(Sgd.) S. ECUYER.

The account of the third flood copied from Pittsburgh Gazette, dated January 13, 1787, is as follows:

The heavy rains and constant thaw for this some time past swelled the Allegheny and Monongahela Rivers to a very great height. Several Kentucky boats passed down, the latter adrift, all of them loaded.

The Allegheny overflowed its banks to such a degree that a great part reserved tract, opposite this place, was under water. The inhabitants of the ferry house were obliged to leave it, and it was with the greatest difficulty they escaped as the flat, canoes, etc., had been carried by the water to what is called the second bank; a great distance from the usual bed of the river. We have not yet received an account of the damage done, but judge it must be considerable.

Col. T. P. Roberts, of the United States engineers, of Pittsburgh, has made a careful survey of the elevation of the old block house and fort, with the conclusion that the flood of January 9, 1762, reached a stage of 36 feet above the zero of our present gage, or 0.5 foot above the great flood of March 15, 1907. A drawing of Col. Roberts' survey is given as figure 1 below.

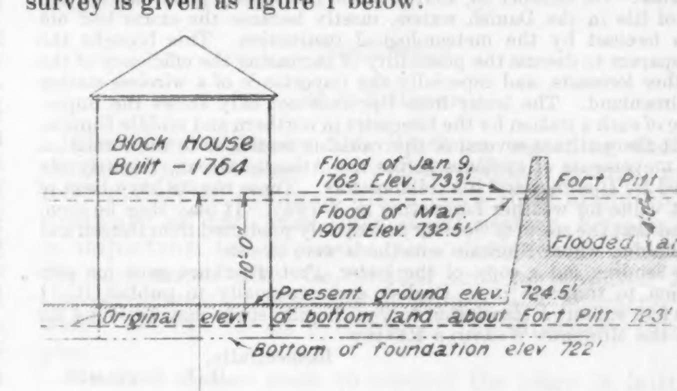


FIG. 1.—Comparison of old and recent floods at Fort Pitt.

If the estimate of S. Ecuyer is correct, the flood of March 6–9, 1763, attained a stage of 37.9 feet above zero of our present gage.

The foregoing records of great floods in the Ohio at Pittsburgh are of great interest because the floods occurred at a time when the drainage areas above Pittsburgh had not been cut over and must have contained large areas of forests in their virgin state.

The two floods above cited were greater than any that have since occurred.

[1] Fort Pitt and Letters from the Frontier, J. R. Weldin Co., Pittsburgh, 1892.

No less interesting, as showing the prevalence of lengthy periods of extremely low water before the forests were removed, is the evidence of the "pictured" rocks in the bed of the river a short distance above Steubenville, Ohio. These large flat rocks lie on the bed of the river, and have been seen but a few times by white men and then for but a short time. On these rocks are cut pictures of men, animals, birds, and fish. The pictures were evidently cut a long time before white men settled in that section. Considering the crude cutting instruments which must have been available to the Indians or their predecessors a long time must have been required in the cutting, which could be done only at times of very low water.

The bottom lands in the forks of the river are usually level. On the strength of Col. Bouquet's statement that the overflow was 10 feet deep during the flood of January, 1762, an idea may be had of the elevation of the flood. The old blockhouse foundations are at an elevation of about 722 M. S. L.

The ground appears to have been raised about 1½ feet about the blockhouse walls since 1764. These assumptions are taken to be approximately correct, and from them it follows that the 1762 flood was about one-half foot higher than the flood of 1907. The area of the fort was probably raised about 6 feet above the bottom land with the material obtained from the wide and deep moat excavated along the three sides of the fort.

THE IMPORTANCE OF WIRELESS WEATHER REPORTS FROM GREENLAND.[1]

By V. BJERKNES.

[Bergen, Norway, Nov. 23, 1921.]

To the EDITOR:

I take pleasure in submitting to you a translation of a letter from Dr. V. Bjerknes, Bergen, Norway, to the Danish explorer, Mr. Einar Mikkelsen, referring to the importance of daily weather aerograms from Greenland. The letter was written at the request of Mr. Mikkelsen, who intended to publish it in the Copenhagen newspaper, *Nationaltidende*. On October 23, 1921, a storm had caused great damage and loss of life in the Danish waters, mostly because the storm had not been forecast by the meteorological institution. This brought the newspapers to discuss the possibility of increasing the efficiency of the weather forecasts, and especially the importance of a wireless station on Greenland. The letter from Bjerknes not only shows the importance of such a station for the forecaster in northern and middle Europe, but it also outlines several of the valuable results as to the formation and movements of cyclones across the Atlantic Ocean, recently obtained by Bjerknes and his collaborators. These results have been of great value for weather forecasting in Norway. It may thus be mentioned that the storm of October 23 was duly predicted from Bergen and Stockholm, where Bjerknes's methods were in use.

In sending me a copy of the letter, Prof. Bjerknes gave me permission to translate it to English and eventually to publish it. I therefore submit a translation to you, hoping space may be found for it in the MONTHLY WEATHER REVIEW.

Respectfully,

H. U. SVERDRUP.

WASHINGTON, D. C., *January 9, 1922.*

At your request for an expression referring to the value of daily weather telegrams from Greenland and related questions, I desire to make the following statement:

A line drawn from the south point of Greenland to the British Islands is crossed in one year by about 200 single depressions, all of which originate to the south or the west of the line and disappear to the north or the east. Every depression reaches an average age of about one week, and can be identified by a typical region of precipitation accompanied by a characteristic distribution of temperature, wind and barometric pressure. This distribution changes in a typical way with the age of the depression, so it is always possible to tell whether a depression is new born, developing, developed to full strength, or dying. A new-born or dying depression moves slowly, but one which is in the period of full strength can move very rapidly; the velocity may reach 150 kilometers an hour, which is sufficient for covering the distance from the south point of Greenland to Denmark in 21 hours. In this phase of development the depression in its structure reminds one of the tropical cyclones, hence the name cyclone, which is commonly used in the meteorological literature.

One of the most important observations during the last years is that these cyclones occur in well-defined groups. Each group consists of 3 to 6, usually 4, single cyclones. On the Norwegian weather maps the groups are now indicated with a number, and the single cyclones in the group with one of the letters, *A*, *B*, *C*, etc. The *A*-cyclone has its path most northerly, the *B*-cyclone is following a path a little more to south, the *C*-cyclone goes still more southerly, and so on. The *A*-cyclone of the next group appears then far north, the *B*-cyclone follows along a more southerly path, and the performance is repeated. A group of cyclones usually passes by in about 6 days. From January 1, 1921, until to-day, November 23, 59 cyclone groups have crossed the line from the south point of Greenland to the British Islands.

The coast of Norway, which has a long extension from south to north, is touched by practically all cyclone groups and usually by every cyclone in the group. The *A*-cyclones can as a rule be designated as arctic cyclones, which is of most consequence for the northern part of the country. The following cyclones, *B* and *C*, are pressing more against the coast, so that *C* often forces its way across the mountains and continues its path over Sweden and Finland. The *D*-cyclone does the same thing, or it chooses the way south of Norway over Denmark, the southern part of Sweden and the Baltic Sea. The *E*-cyclone takes usually a still more southerly path, if it is formed. The cyclone which brought the devasting hurricane over Denmark on October 23, thus, according to the Norwegian list, was an *E*-cyclone, No. *53E*, formed on October 21 west of the British Islands. *D*-cyclones and the following *E* and *F* may have effects as far as to the Mediterranean.

Within the frame of these constant laws the cyclones and groups of cyclones display great mutual differences in strength, velocity of progression, choice of path, and so on. These are the circumstances which make the forecasting of the weather so difficult. If this is to be made with desirable certainty, then the forecasting meteorologist at any time must have a full view not only of the nearest cyclone but of the whole group and its dispositions. One main defect of the weather maps with which the forecaster now has to be content is that they are of too small geographic extent to render this full view of the situation.

[1] Dr. H. U. Sverdrup, who communicated this translated letter, is temporarily in Washington on scientific work relative to the Amundsen polar expedition. This expedition, which contemplates a drift across the Artic Ocean from a point northwest of the Bering Strait to a point between Greenland and Iceland, has been temporarily delayed by an accident to the propellor of the *Maud*, and the vessel is now in dry dock at Seattle. A new start is contemplated in June.—*Editor.*

Here we are at the essential point. If a wireless station were sending daily weather telegrams from one or preferably from a greater number of Greenland meteorological stations, then a cyclone would not often be able to cross the line from Greenland to the British Islands unobserved. It would be possible at an early phase to carry through the classification, which now to a great extent takes place after the cyclones have raged off the coast of Norway. If the forecast can be based upon a reliable classification made at a sufficiently early phase, then one ought not often to be surprised by a devastating storm. For middle Europe, from Denmark to the south, the case will be about this: The cyclones *A*, *B*, and *C* will usually not give occasion for any anxiety. From a distance they will have influence upon the daily weather and be of importance for the forecasts, but they will rarely cause violent storms. But when the *D* cyclone comes, then the meteorologist must be alert.

A special reason why the *D* cyclone and those following often come as surprises is that they are often formed relatively close to the European coast, even within the European region. However, if the meteorologist has had opportunity to study the preceding *A*, *B*, and *C* cyclones closely, then he already at an early phase will know when and where a *D* cyclone may be formed. He further knows that the *D* cyclone in the first 24 hours will not develop any dangerous violence or move with unexpected velocity. But on the second or third day the wind velocities in the cyclone may reach the violence of a hurricane, as was the case with the October cyclone crossing Denmark. Also the tendencies in this respect are evident from the conditions under which the cyclone is formed. In the same way it will be possible at an early phase to decide whether an *E* cyclone will form after the *D* cyclone, and so on.

Therefore, in order to be able from the very beginning to follow this play of the cyclones, which determine the weather of Europe, a wireless station at the south point of Greenland will be of the highest importance. This station will be of great value for Denmark, and a fine gift to the whole of Europe. For the countries with the most exposed positions, Iceland, the British Islands, and Norway, the importance of this station can not be overestimated.

It is evident from the efforts these countries have made to obtain protection that great economic interests are dependant upon reliable weather forecasts. Wireless weather telegrams are now sent from English, Swedish, and Norwegian ships crossing the Atlantic Ocean, and French ships are expected soon to begin. This is a good support, which, however, can never replace a station on Greenland, because the routes of the steamships are so far south that the observations from the ships do not render the full view of the situation. Further, Norway has in this year experimentally established a weather station with wireless on the most inhospitable of all polar islands, Yan Mayen. This station has only been operated a few months, but has already proved so useful that there will hardly be thought of abandoning it. However, weather telegrams from Greenland would be of still higher importance, which is made evident by the following example:

During the period December 1, 1919, to March 15, 1920, between 70 and 80 storms occurred at that part of the Norwegian coast for which the forecasts at that time were issued from Bergen. Not less than 22 of these storms were either not predicted or the issued warnings came too late to be effective. I must add, that these unwarned storms on an average were the most violent. But only six came from the direction in which the station on Yan Mayen now makes us feel safe. The other 16 came the common way from the west, where only telegrams from Greenland can render corresponding safety.

Let me also mention that in addition to these unwarned storms, five or six cases of false alarms occurred. These cases are regarded as the worst mistakes of the forecasters, because they shake the confidence of the public in the storm warnings. But they appear inevitably, because the forecaster, one time after another, has to take a chance and send out a storm warning based upon the first uncertain indications. He knows that if he would wait for the next observation, then the warning would come too late. This is the situation of the forecaster in this and in other countries: on the one hand, the responsibility for great economic values and human life—on the other hand, the responsibility, not to mention the laughter that accompanies the false alarm. What makes the situation so awkward is that the forecaster usually has to form his opinions of the coming weather on an absolutely insufficient foundation. When work of this kind is demanded, then the foundation for such highly responsible decisions must be made as good as possible.

DISCUSSION.

By A. J. HENRY.

The observation by Dr. Bjerknes regarding the occurrence of cyclones in well-developed groups must refer mainly to cyclones which have their origin to the westward of and pass over Northwestern Europe. It is important to emphasize this distinction, otherwise the impression may be created and perpetuated that the occurrence of cyclones in groups is a characteristic which belongs to all cyclones of the Northern Hemisphere.

Seasonal causes seem to control the place in latitude at which cyclones pass onto the Continent of North America. Cyclones of the winter enter the United States from the Pacific most frequently along the coast north of latitude 45°.

South of that latitude the occurrence of winter cyclones is much less frequent; indeed, several years may pass without the occurrence of a single cyclone south of San Francisco, hence we incline to the belief that the rule enumerated by Dr. Bjerknes does not apply to the Pacific coast storms. Bowie and Weightman [1] in their discussion of the different types of cyclones explain the movement in low latitudes as being due to high pressure in Alaska and the western Canadian Provinces. They say, in discussing storms of the Northern Pacific type:

> Storms of this class usually make their appearance on the Washington and Oregon coasts and thence move eastward in widely different courses. There are two, however, that are often followed—one due east along the northern border and the other southeastward from the North Pacific States to the Southern Plains States and at times quite to the Gulf coast and thence eastward or northeastward. During the time of appearance of lows of this type the Aleutian low is well defined, but somewhat south of its normal position, and the pressure is above normal over the interior of Alaska. The Alberta type of disturbance is no longer in evidence and in its stead the pressure is unusually high in that region, the Northern Plains States, and in the

[1] Storms of the United States, Mo. WEATHER REV. SUPPLEMENT No. 1, Washington, 1914.

region of the Great Lakes. A feature of the North Pacific storms is that they do not usually occur singly—that is, when this type appears the first storm will be followed by others of the same type. Frequently this storm prevails with great intensity on the North Pacific coast, but, unless it takes the southeastern track, it loses its marked intensity in crossing the Rocky Mountains.

The total number of cyclones charted each year ranges from 90 to 150 with an average of close to 130 per annum. No attempt has been made to class these storms in the order of their severity, but it is a common observation on the part of the forecasters that the most severe storms almost invariably move poleward rather than from west to east. As a rule storms advancing from the West lack the severity manifested by northeastward-moving storms. Cyclones which move across the United States and southern Canada occasionally tend to form more or less well-defined groups, members of which pursue substantially the same path as, for example, in February and March, 1904, when the Alberta type apparently changed to the North Pacific type, the latter continuing through March. This series affords an excellent example of the tendency of cyclones to move in groups. The table below presents the data of origin and movement chronologically beginning February 1. The data are taken from the MONTHLY WEATHER REVIEW.

TABLE 1.—*Origin of cyclones of February and March, 1904, months when the movement was in fairly well-defined paths.*

[See chart II of the REVIEW for the months named.]

Date.	Apparent origin.		Date.	Apparent origin.	
	North latitude.	West longitude.		North latitude.	West longitude
1904.	°	°	1904—Continued.	°	°
Jan. 31	51	114	Feb. 27	38	105
Feb. 4	48	125	Mar. 1	48	125
7	43	113	3	33	115
11	47	125	8	51	120
12	53	103	10	48	125
15	47	125	14	45	125
19	51	104	17	48	125
20	29	94	19	48	125
22	42	107	22	48	125
22	53	125	28	42	108
23	47	122	Apr. 3	51	120
26	52	120	5	49	125

By E. H. BOWIE.

In applying the principles outlined by Dr. Bjerknes one should understand that they specifically apply to that part of the North Atlantic Ocean east and north of a line drawn from the south point of Greenland to the British Isles; also that his reference to "depressions born to the south or west of this line," does not mean that they actually had their origin immediately south or west of this line, but that some of them may have formed over the ocean and many others no doubt first crossed the American Continent. Also we must understand that the *A*, *B*, *C*, *D* storms may be of the same intensity, but since the *A* and *B* storms cross the longitude of Norway in high latitudes, that country does not become involved in the full intensity of these two types; later, *C* and *D* storms come along, moving in lower latitudes, and sweep over central and southern Norway and the full intensity of them is there experienced.

There is reason to believe that a grouping of cyclones similar to those described by Dr. Bjerknes is frequently noted on the weather charts of the United States and Canada, but the groups do not follow a hard and fast rule; it is a strong tendency rather than an inflexible law. This fact was brought out in the paper on the "Storms of the United States and their average movement," by by Bowie and Weightman, wherein it was stated:

The variations in position and magnitude of the elongated subpermanent area of low pressure that normally extends from southeastern Alaska to Kamchatka have a decided influence on the character of and courses followed by storms (cyclones) that cross the United States. If this Aleutian LOW is north of its normal position, LOWS will move far south of their normal tracks and stormy weather with great alternations in temperature will occur over the United States. The paths of storms which cross the United States shift (north and south) with the position of the Aleutian LOW. For example, when after a period of indifferent pressure (compared with the normal) within the Aleutian area the pressure in this region begins to fall, a LOW will appear within 36 hours north of Montana; as the Aleutian LOW deepens, LOWS will follow each other in rapid succession along the northern border until the pressure begins to rise north of the Aleutian area and it (the Aleutian LOW) moves south of its normal position, when the tracks of LOWS in the United States will shift to lower latitudes. Finally, when the Aleutian LOW reaches its southernmost position, LOWS crossing the United States will make their first appearance in the southern Plateau region or over the Gulf of Mexico.

Also in a paper on "The Planetary System of Convection," by W. R. Blair, in the MONTHLY WEATHER REVIEW, April, 1916, there will be found on page 194 the following:

Some years ago Mr. E. H. Bowie called the writer's attention to the fact that the low-pressure areas enter and cross the United States in *series*. The first low-pressure area in such a series will enter the country well to the north and pursue a course eastward over the Northern States, the second enters somewhat farther south, and so on. The last low-pressure area of the series may enter the extreme Southwest and pass along the Gulf and Atlantic coasts, although the series do not always carry as far south as this. The series follow each other in close succession. The relation between these series of low-pressure areas and the general meridional movement of the atmosphere seems to be quite direct.

There can be no question that there is a similarity between the progressive southward movement of storm tracks in series over the United States and western Europe, but, as stated before, the sequences do not follow any hard and fast rule. Also, it is not infrequently noted that at times LOWS crossing the United States will group themselves by type—that is, there will be several successive LOWS of the Alberta type or several of the Colorado type. The Alberta type continues when the Aleutian low-pressure system is normal or slightly north of normal in position and the departures from normal pressures therein are of no great consequence.

Figure 1 illustrates three series of LOWS that crossed the United States during March, 1916. The similarity of these series to those referred to by Dr. Bjerknes is apparent.

The importance of radioed weather reports from Greenland to the meteorological services of Europe can not be too strongly urged. Reports from that continent will link the areas of meteorological observation of North America and Europe, bridge the Atlantic, and give the forecaster of Europe an outlook as to coming changes comparable with that now had by the forecaster at Washington. Moreover, many times such reports would be of great value in weather forecasting in the United States, for it is the writer's belief that the abnormal retardations in the eastward movement of high and low pressure areas across the United States are brought about by abnormal conditions over Greenland.

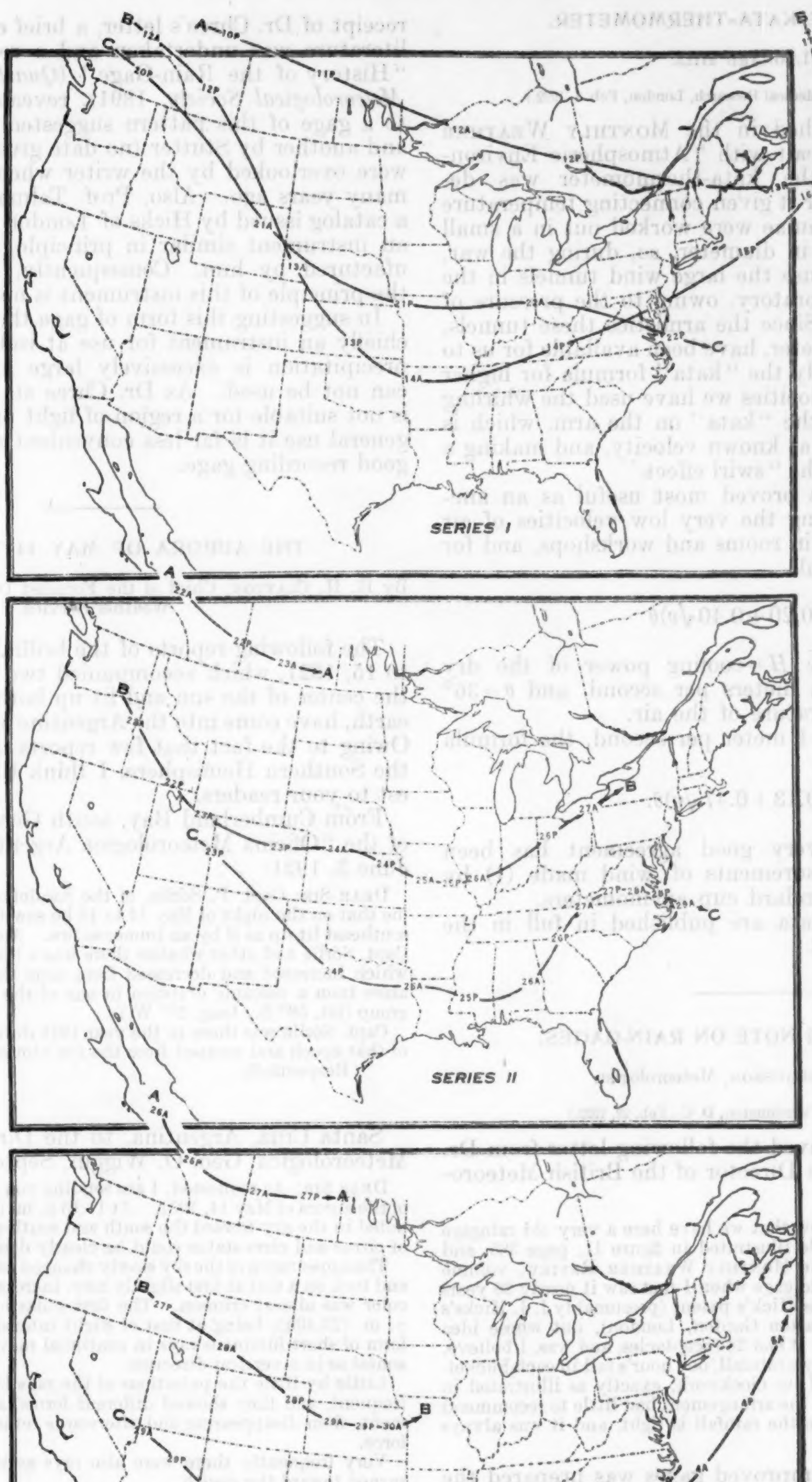


FIG. 1.—Three series of low-pressure groups, March, 1916, similar to those described by Dr. Bjerknes.

NOTE ON THE KATA-THERMOMETER.

By LEONARD HILL.

[National Institute for Medical Research, London, Feb. 1, 1922.]

In an article published in the MONTHLY WEATHER REVIEW,[1] in which I dealt with "Atmospheric Environment and Health," the kata-thermometer was described and formulae for it given connecting temperature and wind. These formulae were worked out in a small wind tunnel 12 inches in diameter, as, during the war, it was not possible to use the large wind tunnels in the National Physical Laboratory, owing to the pressure of airplane work there. Since the armistice these tunnels, from 3 to 7 feet in diameter, have been available for us to redetermine very exactly the "kata" formula for higher velocities. For low velocities we have used the whirling arm method, rotating the "kata" on the arm, which is moved through the air at known velocity, and making a suitable deduction for the "swirl effect."

The dry "kata" has proved most useful as an anemometer for determining the very low velocities of air movement which exist in rooms and workshops, and for this purpose the formula

$$H = (0.20 + 0.40\sqrt{v})\theta$$

should be used, where H = cooling power of the dry "kata"; v = velocity in meters per second, and θ = 36°.5 C. minus the temperature of the air.

For velocities above 1 meter per second, the formula to be used is

$$H = (0.13 + 0.47\sqrt{v})\theta.$$

Using this formula, very good agreement has been obtained between measurements of wind made (1) by the "kata," (2) by standard cup anemometers.

The formulae and data are published in full in the *Proc. Roy. Soc. B*, 1922.

A CORRECTIVE NOTE ON RAIN-GAGES.

By S. P. FERGUSSON, Meteorologist.

[Weather Bureau, Washington, D. C., Feb. 23, 1922.]

The EDITOR has received the following letter from Dr. Charles Chree, Assistant Director of the British Meteorological Office:

It may interest you to know that we have here a very old raingage which embodies the principle illustrated in figure 11, page 385, and described on page 384 of the MONTHLY WEATHER REVIEW, volume 49 (July, 1921). It was an old gage when I first saw it nearly 30 years ago. The gage is described as Hick's patent (presumably J. J. Hicks's the instrument maker of Hatton Garden, London), but whose idea it represents I do not know. It had 24 receptacles, and was, I believe, intended to record a single day's rainfall, one hour's fall in each bucket. The spout was carried round by clockwork, exactly as illustrated in figure 11. For a daily record the arrangement had little to recommend it, especially at places where the rainfall is light, and it was always regarded here as a curiosity.

When the paper on improved gages was prepared the writer examined available descriptions of recording and totalizing gages published during the past 25 years without finding an instrument suggesting the multiple-collector gage referred to as "new." Following the receipt of Dr. Chree's letter, a brief examination of older literature was undertaken and a rereading of Symon's "History of the Rain-Gage" (*Quarterly Journal, Royal Meteorological Society*, 1891), revealed a brief reference to a gage of this pattern suggested by Leupold (1726), and another by Stutter (no date given); these references were overlooked by the writer when reading this paper many years ago. Also, Prof. Talman kindly supplied a a catalog issued by Hicks of London in 1887, illustrating an instrument similar in principle, patented and manufactured by him. Consequently, the statement that the principle of this instrument is new is incorrect.

In suggesting this form of gage the writer had in mind chiefly an instrument for use at isolated stations where precipitation is excessively large and recording gages can not be used. As Dr. Chree states, this instrument is not suitable for a region of light precipitation, and for general use it is far less convenient and accurate than a good recording gage.

[1] 48: 687-690, 1920.

THE AURORA OF MAY 14 TO 15, 1921.

By H. H. CLAYTON, Chief of the Forecast Division of the Argentine Weather Service.

The following reports of the brilliant aurora of May 14 to 15, 1921, which accompanied two immense spots near the center of the sun and lit up both hemispheres of the earth, have come into the Argentine Meteorological Office. Owing to the fact that few reports of aurora come from the Southern Hemisphere, I think these will be of interest to your readers.

From Cumberland Bay, south Georgia, to the director of the "Oficina Meteorologica Argentina," G. O. Wiggin, June 3, 1921:

DEAR SIR: Capt. P. Sórlle, of the Sandefjord Whaling Co., informs me that on the night of May 14 to 15 he saw the entire sky toward the southeast lit up as if by an immense fire. According to the account of Capt. Sórlle and other whalers there was a magnificent display of light which increased and decreased from time to time. They thought it arose from a volcanic eruption in one of the islands of the Sandwich group (lat. 58° S., long. 25° W.).

Capt. Sórlle was there in the year 1911 during the volcanic eruption of that epoch and escaped from the fire almost by a miracle, etc.

Respectfully,

THORLEIF HOXMARK.

Santa Cruz, Argentina, to the Director of the Oficina Meteorologica, Geo. O. Wiggin, September 9, 1921:

DEAR SIR: As requested, I am sending you the following description of the aurora of May 14, 1921. At 11:15 p. m. (23:15h) a luminosity was noted in the sky toward the south and south-southwest, so that a layer of cirrus and cirro-status could be clearly distinguished.

The appearance of the sky slowly changed as the luminosity increased and took on a tint at first slightly rosy, increasing in intensity until the color was almost crimson. The first pulsations were visible at 11:40 p. m. (23.40h), being at first of slight intensity and appearing in the form of short luminous rays in continual movement, as well in a horizontal as in a vertical direction.

Little by little the pulsations of the rays became stronger and more frequent, and they showed different forms, at times in visible movement, then disappearing and afterwards returning suddenly with new force.

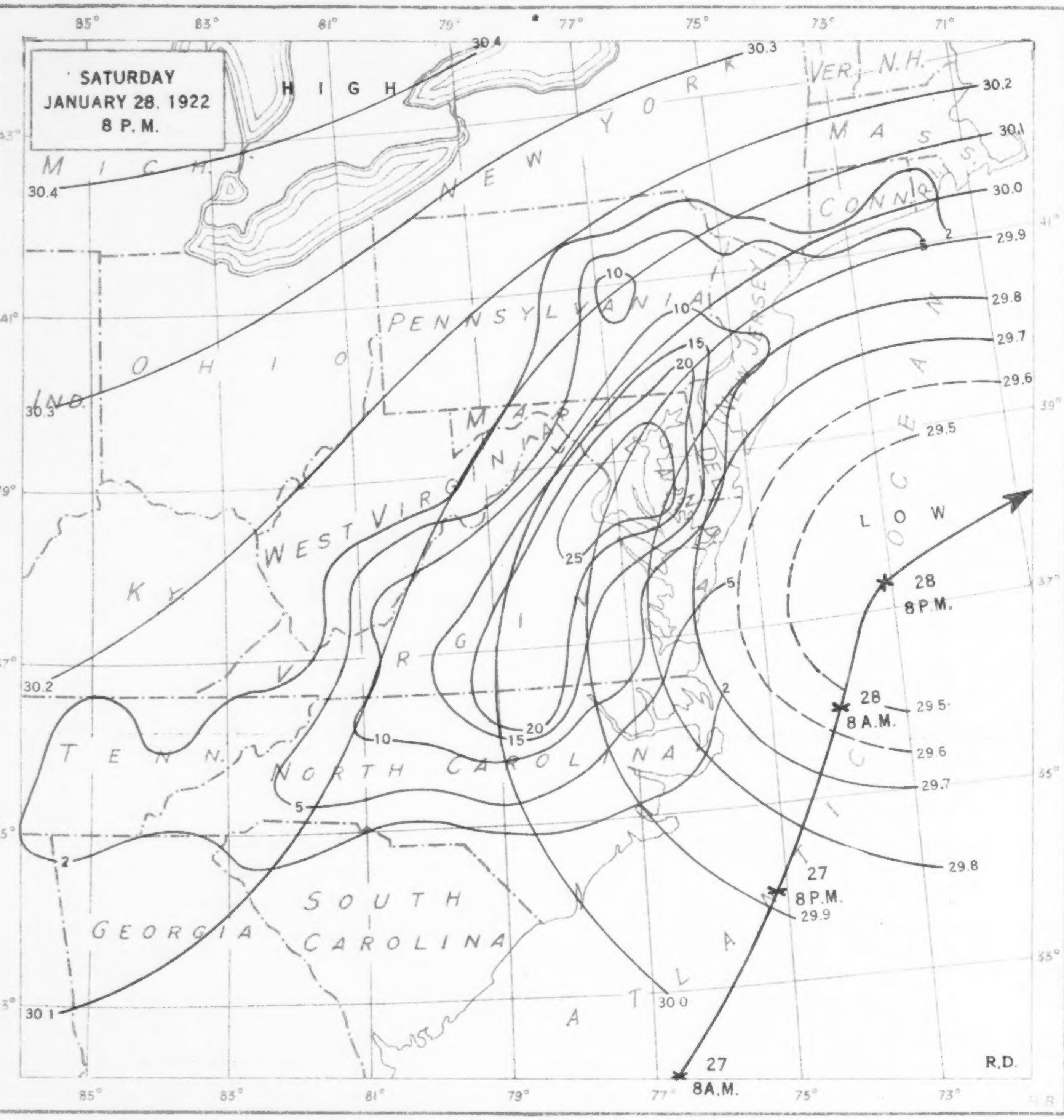
Very frequently there were also rays as if a searchlight had been turned toward the zenith.

The spectacle lasted until 1:30 a. m. of the 15th, gradually decreasing in intensity and frequency, and finally there only remained the last-mentioned rays, which were directed toward the zenith.

There are some persons who say that the rays were seen until 4 to 5 a. m. of the 15th.

Respectfully,

H. WANGO.



Black lines indicate distribution of barometric pressure at 8 p. m. (75th meridian time), January 28, 1922, with the track of the storm; red indicates the total depth of snowfall, in inches, during the period January 26–29, 1922.

THE GREAT SNOWSTORM OF JANUARY 27-29, 1922, OVER THE ATLANTIC COAST STATES.

By P. C. DAY and S. P. FERGUSON.

[Weather Bureau, Washington, D. C., Mar. 2, 1922.]

This unusual snowstorm accompanied a shallow barometric depression which first appeared south of Florida on the morning of the 26th and moved northeasterly off the Atlantic coast with decreasing velocity but with little change in intensity, until it reached the latitude of southern Maryland where, due to high barometric pressure, its northward movement was effectually blocked and its course was changed to the eastward. After passing over the Florida Peninsula its course lay off the coast during its entire passage northward, its nearest approach to land occurring during the afternoon of the 28th, when its center was apparently slightly more than 100 miles off the Maryland coast. (See chart P.C.D.-I.)

TIME OF SNOWFALL.

The snowfall connected with this storm was of little importance till late in the forenoon of Thursday, the 26th. By noon of that day snow had begun to fall in southeastern North Carolina and north-central South Carolina. Between noon and midnight the snowfall front advanced northward at the rate of about 10 miles per hour, so that at midnight snow was falling over practically all of North Carolina and in most of the southern border counties of Virginia.

By noon of Friday, the 27th, the snowfall front had reached northern Accomac County, Va., to eastward of Chesapeake Bay, and the vicinity of Charlottesville, Va., to the westward. The rate of fall, however, was only moderate in the eastern portion of Tidewater Virginia, but rapid in the western portion and in all of middle Virginia that had yet been reached. West of the Blue Ridge again the rate of fall was less.

During the afternoon and evening of the 27th the front of the storm advanced a little more rapidly than before in the districts between the Blue Ridge and the eastern shore of Chesapeake Bay, but rather slowly near the ocean shore. By midnight of the 27th-28th snow was falling over a large part of Delaware and over a little of southwestern New Jersey, while the southernmost portion of Pennsylvania, westward to Franklin County, had been reached. By this time the end of the snow had occurred in the westernmost portions of the Carolinas and in far southwestern Virginia.

During the first half of Saturday, the 28th, the storm front continued to move northeastward, till by noon snow was falling over about two-thirds of the eastern half of Pennsylvania, nearly all of New Jersey, small parts of Long Island and Connecticut, but much of Rhode Island and southeastern Massachusetts. The later extension of the snowfall area was chiefly to the northwestward, or roughly perpendicular to the direction of advance in the low-pressure center. The inflow of air from the northwestward had apparently become more rapid, and in elevated districts from the Catskills southwestward to West Virginia snow now set in considerably beyond the previous limit of fall in connection with this storm; yet the total falls here were not large. In New England there was but little northward extension of the area after the daytime of the 28th, and the total fall where greatest was only moderate. This was due to the turning eastward of the storm center, which is indicated on Chart P.C.D.-I.

The snowfall finally ended usually during the daylight hours of Sunday, the 29th, in the easternmost parts of Virginia and in most portions of the States to the northeastward. At most stations in New England and on Long Island the end came before 10 a. m., but at some coast stations of New Jersey between 10 and noon, while in parts of Tidewater Virginia and in the mountain portions of several States light snow continued till an afternoon hour, or locally till after dark.

TOTAL DEPTH.

The greatest reported total depth of snow from this one storm, where the depths were taken at numerous points so as to eliminate the results of drifting, was 36 inches at Roxboro, Person County, in north-central North Carolina. At no other point in that State, or anywhere to southward of the James River in Virginia was the fall more than 25 inches, as far as known, but from the vicinity of Fredericksburg, Va., northeastward to about the mouth of the Susquehanna River, including several points on the Eastern Shore of Chesapeake Bay, from Dorchester County, Md., northward, the depths were from 24 to 30 inches. The area which received as much as 15 inches is a belt about 100 to 130 miles in width, extending from about Durham, Orange, Alamance, and Guilford Counties, N. C., northeastward. On the James River the area extends from a few miles east of Richmond to about 30 miles west of Lynchburg, and on the Potomac from eastern Westmoreland County to eastern Loudoun. On the southern border of Pennsylvania the 15-inch area reaches from western York County eastward to the Delaware River, but to northeastward of the border it tapers rapidly. The depths for almost the entire area of snowfall are indicated on chart VIII.

The total snowfalls in some of the larger cities were: Raleigh, 9.5 inches; Richmond, 19.1; Washington, 28; Baltimore, 26.5; Wilmington, 18; Philadelphia, 12.3; Trenton, 10.8; New York, 7; New Haven, 3. At Washington, D. C., the official measurement of 28 inches is 8 inches larger than the amount measured during the memorable storm of February 11-13, 1899, and is the greatest depth recorded at that place since precise measurements were begun by the Weather Bureau.

Where the fall was heavy, the snow was generally light and dry, so did not lodge on tree branches and especially on wires as extensively as often happens during moderate falls. There was especially little interruption to wire service for so severe a storm. Traffic on steam and trolley lines and on highways was considerably hindered, but in the States northeast of Maryland the Weather Bureau warnings that deep snow should be looked for had led to thorough preparations to remove the snow as quickly as possible. As a result the main highways in several States, notably New Jersey, were completely cleared for traffic within comparatively few hours after the snowfall ceased.

A number of reports have been received of buildings collapsing from the weight of snow. This weight on roofs was probably greater per square foot at the close of the storm, in a large area from Maryland to North Carolina, than at any time since 1899; indeed, in portions of this area it was apparently greater than ever before observed within living memory.

At Washington, D. C., careful study of the leading features has been made. The meteorological phenomena, other than the snowfall, were remarkably steady through-

out the storm (see fig. 1). The temperature rose slowly, reaching the melting point shortly after the snow ended, the velocity of the wind also rose slowly and steadily, reaching a maximum shortly before the time of minimum pressure and the direction backed from NE. to N. The density of the snow was comparatively small, except during the last few hours of the storm when the temperature neared the melting point. There was little drifting, the depth varying but a few inches at any of the places where measurements were obtained.

WATER-CONTENT (DENSITY) OF THE SNOW

	Inches.
From two sections by sampler in front of Central Office, January 28, 2:30 p. m.	2.33
Total of storm, from section by overflow attachment of rain gage, January 30, a. m.	3.02
Total of storm, from amounts collected in gage on roof of main building of Central Office (melted and measured)	2.18
Total of storm, from record of weighing gage on roof of Instrument Division corrected to agree with sections and for evaporation	3.08
Evaporation, January 29 and up to noon on the 30th (recorded by weighing gage)	.04

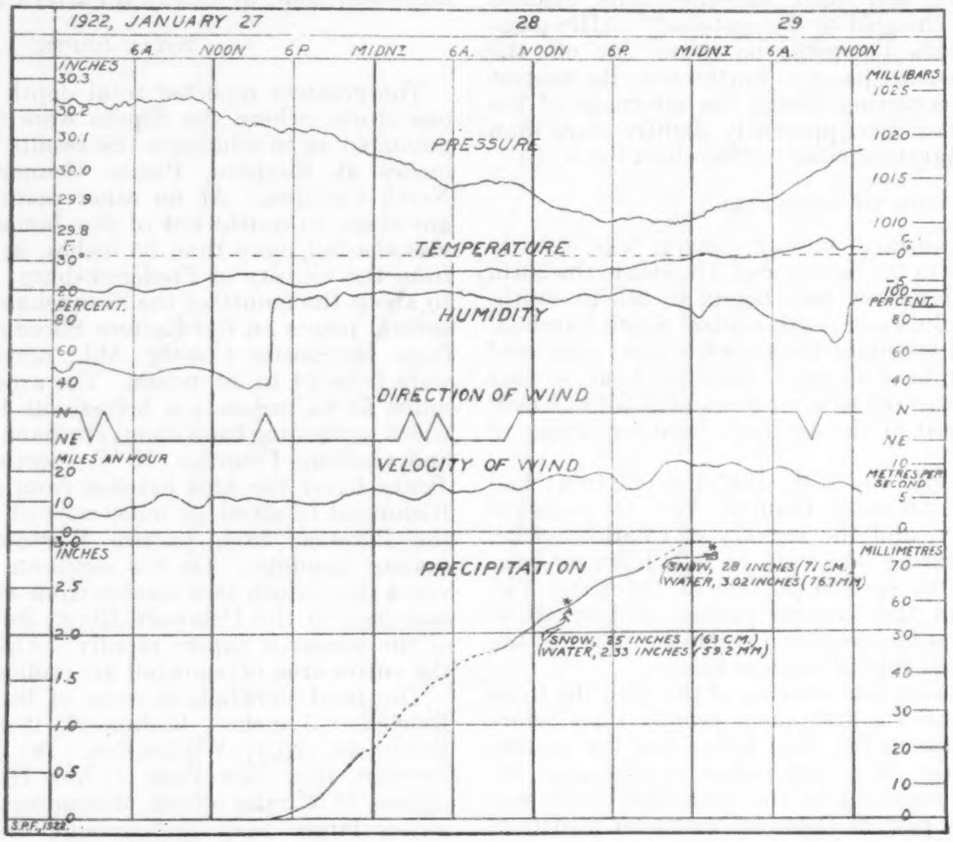


FIG. 1.—Meteorological phenomena at Washington, D. C., during the great snowstorm, January 27-29, 1922.

THE DEPTH OF THE SNOW IN AND NEAR WASHINGTON.

The following measurements are reported by officials of the Central Office:

	Average inches.
At open space in front of Central Office:	
January 27, 8 p. m.	2
January 28, 11 a. m.	22
January 28, 2:30 p. m. (10 measurements, varying between 22 and 30 inches)	25
In Washington Circle, 2,000 feet southeast of the Central Office:	
January 28, 11 a. m.	19
January 29, a. m.	28
In DuPont Circle, five-eighths of a mile northeast of the Central Office, January 28, 3 p. m. (10 measurements, varying between 21 and 28 inches)	24
In vacant lot, New Hampshire Avenue and Seventeenth Street, nine-tenths of a mile northeast of Central Office, January 28, at 3:15 p. m. (5 measurements, varying between 22 and 29 inches)	25
In vacant lot, New Hampshire Avenue and Fifteenth Street 1⅓ miles northeast of Central Office, January 28, 3:30 p. m. (5 measurements, varying between 21 and 28 inches)	24
In open space near Rock Creek Park, 3 miles north of Central Office, January 29, measurements varying between 27 and 38 inches	33
Near East Falls Church, Va., 7½ miles southwest of Central Office, January 29, measurements between 24 and 36 inches	28

RECORD FROM RECORDING GAGE.

The continuous record of precipitation in figure 1 is based upon a partial record (reproduced in fig. 2) from a weighing-recording gage on the roof of the Instrument Division. The capacity of this instrument is but 8 inches of snow; consequently its receiver became full at 11:30 p. m. of the 27th. The broadening of the trace (B) between that time and 9:15 a. m. of the 28th was caused by the settling of the snow filling the funnel above the receiver. At 9:15 a. m. the rate of fall had decreased considerably, and assuming that the end of the storm was approaching, about one-half of the snow was removed from the receiver without otherwise disturbing the instrument in order that the record might be completed on one sheet; the resumption of the record is indicated at (C). However, after 10 a. m. the rate increased again and at 1:45 p. m. it became necessary to empty the instrument and begin a new record (indicated at D); but the storm continued, the receiver filled for the third time before 8:30 p. m., and there is no record for the remaining four hours of the main storm. The relatively dense snow occurring after 8:30 p. m. filled the funnel and after the

temperature rose above freezing, slowly melted, causing the rise in the tracing (or an apparent record) at (E). A few light sprinkles of snow and rain between 10 a. m. and noon of the 29th did not exceed 0.01 inch and are not indicated. About 0.04 inch (1 mm.) of this precipitation evaporated before the record sheets were changed on the 30th, as indicated by the slow fall of the tracing at (F). The amount of melted snow in the receiver was 0.76 inch, or exactly the same as that recorded, allowing for evaporation. The tracing at (G) is composed of the two records (D) and (E) connected with the first record (A) by an interpolation based upon the rate of fall, observations, and the various measurements already referred to. The results from these data are in very close agreement, doubtless because of the remarkably uniform conditions of wind and temperature prevailing during the storm. The very small catch of the recording gage (only one-half of the total obtained by sampling) is due to the exposure of the instrument on a small platform in the center of a sloping roof which deflects the wind upward and prevents much snow from reaching the gage. However, since there is no lag in instruments of this kind,

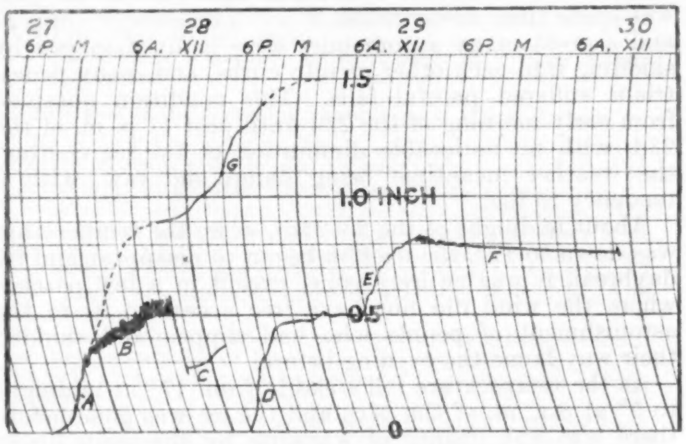


FIG. 2.—Record of weighing-gage of snowfall of January 27–29, 1922.

readings from a deficient record can be corrected by a constant, without errors of importance, to agree with accurate totals, provided, as in the present instance, the conditions are constant during the period covered by the record.

OTHER REMARKABLE STORMS.

Satisfactory data for comparisons of the recent storm with other severe storms of the past are available only after 1883, and the automatic record of snowfall at Washington and New York was not begun until 1893. At Central Park Observatory, New York, Dr. Draper's recording gage has been in use since 1875, but this instrument is exposed on a roof and the snow is melted by heat as it falls; consequently the record is variably deficient. The automatic record at Blue Hill Observatory, Massachusetts, begun in March, 1886, is the longest and probably the most complete available, three recording gages having been in use since 1889, at different heights within a space of 2½ miles.

Of remarkable snow storms occurring near the Atlantic coast, that of January 17, 1867, in New England was one of the most severe, the average depth reported in Dorchester (south of Boston) being about 5 feet; this depth has not been exceeded since, except possibly in the great blizzard of March 11–14, 1888, when the average depth in irregular areas in the valley of the Hudson River and in central Connecticut amounted to or exceeded 40 inches. A conspicuous feature of this storm was the rather high and variable density of the snow which varied from about 9 per cent at stations farthest from the coast to nearly 30 per cent near the coast of southern New England, as shown by Prof. Upton's excellent study of this storm published in the American Meteorological Journal, May, 1888.

The only automatic record from which the rate of fall may be ascertained was obtained at Blue Hill Observatory, but here, as well as at other places very near the coast, much of the precipitation occurred in the form of rain or rain mixed with snow; the maximum rate definitely known to be of snow was about 2 inches an hour. Next in importance are the storms of January 31–February 1, 1898, and November 26–27, 1898, in New England, and that of February 8–14, 1899, which, occurring during a severe cold wave, covered the entire region between South Carolina and Maine. The first two are of interest because of the rapid rate of fall as well as large total for the storm, and the last for its great extent and the unusually low temperature that prevailed during its passage. The comparison below shows that the rate of fall for short intervals during the storm of January 27–29, 1922, while rapid, is not excessive, but that the total for 24 hours or for the entire storm is one of the largest on record. The automatic records at Washington and New York are incomplete for the storm of February 11–13, 1899, and the comparison with data for New England is not strictly accurate; but no other data are available.

RECORDED AT BLUE HILL, MASS.

Storm.	Maximum rate of fall of snow (water content, or melted snow) in—						Duration of storm (hours).
	1 hour.	2 hours.	6 hours.	12 hours.	24 hours.	Entire storm.	
1898.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	
Jan. 31–Feb. 1	0.36	0.56	1.18	1.63	2.20	2.20	24
Nov. 26–27	0.28	0.48	1.12	1.60	1.92	2.00	28
1899.							
Feb. 13–14	0.15	0.22	0.42	0.60	1.00	1.30	48

RECORDED AT WASHINGTON, D. C.

Storm.	1 hour.	2 hours.	6 hours.	12 hours.	24 hours.	Entire storm.	Duration of storm (hours).
1922.							
Jan. 27–29	0.21	0.37	0.94	1.48	2.47	3.02	32

The total depth measured during the storm of February 11–13, 1899, was at Boston (Blue Hill), 14 inches; Washington, 20 inches.

COMPARISON OF METHODS OF MEASUREMENT.

The various measurements of depth and density of snow during the recent great storm are in unusually close agreement, chiefly because of uniform conditions.

The importance of an automatic record of snowfall or of frequent measurements is clearly indicated by a comparison of the automatic record at Washington on January 27–28 with the measurements of depth and density. Between 2:30 p. m. of the 28th, when the water content of a depth of 25 inches was 2.33 inches, and the end of the storm, 10 hours later, the depth on the ground increased but 3 inches, while the total water content increased 0.69 inch. This apparent increase of density

was almost wholly due to settling of the snow on the ground; the actual density increased but little up to 8 p. m. of the 28th and does not appear to have exceeded 12 per cent. The rate recorded up to 8:30 p. m. of the 28th is fairly uniform and the total during the preceding six hours was 0.46 inch; this, as already explained, must be deficient, hence, accepting the official total of about 2.5 inches between 8 p. m. and 12.30 a. m., the amount falling after 2:30 p. m. was at least 8 inches, which brings the total of the storm to at least 33 inches. An equivalent or larger amount probably could have been obtained by the measurement, at regular intervals, of snow falling upon a suitably exposed platform that could be swept after each measurement. The shrinkage of depth of snow on the ground at times will equal the rate of fall; it is due chiefly to settling, but partly to evaporation, and is obviously most rapid at the end of the storm, but continues indefinitely. The shrinkage following the recent storm as shown by daily measurements at 8 p. m. is as follows, the figures representing depths: January 29, 23 inches; January 30, 19 inches; January 31, 17 inches.

The capacity of a recording snow gage preferably should be sufficient for the largest fall probable in one storm. That of the standard model of the instrument in operation during the recent storm is about 14 inches and the area of the receiver is 1.4 times that of the collecting funnel; consequently, to enlarge its capacity to 28 inches, it will be necessary to increase the depth of the receiver to 21 inches and the height of the instrument from 26 to 35 inches. If the instrument can be inspected twice a day the capacity can be increased to 18 or 20 inches only, with small probability of loss, since, as already indicated, the receiver can be partially emptied without disturbing the recording mechanisms. An instrument of this capacity will be 30 inches high instead of 26, and its receiver 15 instead of 11 inches deep. If the capacity of the recording gage during the recent storm had been 14 inches instead of 8, the loss of record would have been limited to the period of five or six hours ending with 9:15 a. m. of the 28th.

The small catch of the gages on the roofs confirms experience; the catch of roof-exposed gages is always deficient except when fairly dense snow falls during a calm—a condition of very rare occurrence—and generally, even when the conditions might be considered favorable, measurements on a roof are seldom better than estimates. The use of such data (always subject to correction) is advisable only when an approximate value is desired for immediate use. Deficient values from a recording gage, as already stated, can be corrected to agree with more accurate totals obtained by sampling; but it will be far better to expose all gages on the ground in a suitable place and discontinue entirely all attempts to measure snow on roofs. The best results are obtained when gages on the ground, whether used for rain or snow, are equipped with Nipher screens and placed inside an inclosure, made of coarse wire cloth, the walls of which are about 1 yard high and distant about twice their height from the gages; but even one good installation of this kind, suitable for most circumstances, may be inadequate during extremes of wind or weather and require to be supplemented by measurements at several other places. The standard of measurement for snow should be that of the "section" cut from snow on the ground (preferably by a sampler, although the overflow receiver of the standard 8-inch gage will do), the water content of which is determined by weighing.

UNUSUAL DISAPPEARANCE OF GLAZE AT TOPEKA, KANSAS.

By S. D. FLORA, Meteorologist.

[Weather Bureau, Topeka, Kans., Jan. 11, 1922.]

The night of December 23–24, 1921, witnessed an unusual phenomenon in the way of disappearance of glaze at Topeka with temperatures continually below freezing.

A misting rain on the 22d, falling with temperatures ranging from 19° to 26°, had frozen as it fell, coating sidewalks, paved streets, trees, wires, and even unsurfaced country roads with a film of ice, or glaze. While less than a measurable amount of rain fell and the film was quite thin, nevertheless it was exceedingly slippery and a great many automobiles were badly damaged by skidding into each other or into curbs, and many pedestrians suffered painful falls. This condition obtained from early morning of the 22d until past 11 p. m. of the 23d, with no noticeable diminution of the ice coating, the weather meantime being damp and raw, with a tendency to fog.

About midnight of the 23–24th, when the temperature was down to 17°, the ice film began to disappear and by daybreak it was entirely gone, except in a few patches where the wind did not have free access to it, to the astonishment of people who had slipped and skidded their way home the evening before.

As the temperature fell steadily from 17° at midnight to 5° at 8 a. m. of the 24th and the ice was gone before there was any chance of warming by the sun's direct rays, the plausible supposition is that it had been evaporated, though the absence of details with respect to the vapor content of the air at the time makes it impossible to corroborate this theory.

There was no shift of the wind, which was from the north all night, to account for the advent of a drier stratum of air. The barometer also made no change in its tendency, but continued a steady rise, which began at 2 p. m. of the 23d, with a station pressure of 28.82 inches, and culminated at 11 a. m. of the 24th at a station pressure of 29.36 inches.

The sequence of weather as read from the daily weather maps was as follows:

22d. Light southerly winds, with sprinkles of rain.

23d. Wind shifting to north and northeast, with falling temperature.

24th. Wind shifting to northwest, with lower temperature. It is possible this tendency to a northwest wind over the surrounding country brought a drier stratum of air, though no measurements of its moisture content at Topeka are available.

NOTES, ABSTRACTS, AND REVIEWS.

ROME MEETING OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS.

The agenda for the Rome meeting of the International Union of Geodesy and Geophysics have just been received, and a translation is published herewith:

International Union of Geodesy and Geophysics.

ASSEMBLY IN ROME CALLED FOR MAY 2, 1922.

SECTION OF METEOROLOGY.

Order of the Day.

1. Communication of the Chairman on the constitution of the Section.
2. Organization of the Committee of the Section.
3. General consideration of scientific and practical objects of the Section.

Ultimate relations with other Sections of the Union, with other meteorological associations, and with academies of science.

Communication of the Officers to the Union—letter from Switzerland.

4. Scientific questions proposed by the various national committees.

Proposals of the National Committee of France.

1. The different kinds of thunder storms, and more generally the atmospheric electric phenomena.
2. The clearness of the atmosphere and associated optical phenomena.
3. The different kinds of clouds.
4. The forecasting of weather, and particularly the method of [barometric] tendencies.

Proposals of the National Committee of Great Britain.

5. *The study of the upper atmosphere by sounding balloons.*—What the regions are in which there is need for new researches, and what the probabilities are for obtaining observations in the given regions.

6. *Relation between vertical convection and horizontal movement.*—Certain experiments seem to indicate that the mechanical effect of the penetration through the upper layers ought to determine the convergence of aerial currents, and thus provoke movements of one form or another, having the nature of eddies displacing themselves in a horizontal direction.

Evidence is desired, based on observation, of the nature and extent of the displacement of air by convection; also concerning the real trajectory of air in motion taking account of both horizontal and vertical motion.

7. *The control of movements of air in the stratosphere and the troposphere.*—The movement of air in the troposphere such as has been actually observed ought to be largely influenced by penetrating convection, but the same influence can not be very considerable in the stratosphere, which (and it is generally admitted) is not subjected to penetrating convection. The displacements produced in the stratosphere ought therefore, to be less complicated than in the troposphere, and the laws which control them ought to be simpler.

It is necessary to consider the displacements of air in the stratosphere, both from the point of view of theory and of observation. Mr. W. H. Dines has submitted the results of observations which seem to indicate that in England there exists a relation between variations of pressure and variations of temperature, very close and direct in the troposphere, but not so close and in an inverse sense in the stratosphere. The simultaneous values of temperature, pressure, and wind direction in the stratosphere are worthy of attention.

8. *Radiation and its influence on the temperature of the surface, the air and the sea.*—It is strongly desired that the time element be studied in relation to radiation phenomena in the atmosphere. The theories generally suppose the existence of final conditions, and the question of knowing how much time is necessary for final conditions to be attained is of prime importance.

9. *Relation between visibility at the surface and the quantity of dust in the surface layers.*—The committee advises the study of the pollution of the atmosphere and suggests two methods for determining effectively the proportion of impurities suspended as solids in the air. The first determines by filtration the proportion of solid matter existing in two liters of air; in the other the solid impurities contained in 50 cc. are projected on to a thin plate of glass in such a manner that they may be examined.

The question of visability and of atmospheric impurities are of international interest. This study is ready for international collaboration.

10. *The composition of the atmosphere in the upper layers.*—There is too much difference between the results of different investigators on the composition of the atmosphere at altitudes above 20 kilometers.

According to different investigators the composition of the extreme layers of the atmosphere is (1) hydrogen, (2) geocoronium, or (3) helium.

If we succeed in agreeing upon the process of computation and on the results, the differences must necessarily depend upon the data to which this computation is applied. It is important, therefore, to approve new steps for the solution of this problem and to know whether it is a question of the revision of calculation methods or of new experiments, in order to obtain satisfactory data for carrying on the calculation.

The atmosphere above 20 kilometers presents such problems as (i) the composition, density, and temperature of the air at different heights, (ii) the aurora and its spectrum, (iii) the electromagnetic phenomena and their relation to various magnetic variations and irregular magnetic perturbations, and (iv) the absorption of solar rays which do not penetrate as far as the lower strata.

Proposals of the National Committee of Italy.

11. *Meteorological data in relation to modern methods of statistics.*—The methods of presenting the normal values of the different climatological elements with regard to the demands of modern statistical methods.

—*C. L. M.*

RAINFALL AT PAGO PAGO HARBOR, TUTUILA, SAMOA.

Through the courtesy of Capt. W. Evans, United States Navy, Governor of American Samoa, and Lieut. F. C. Nyland, United States Navy, superintendent of public

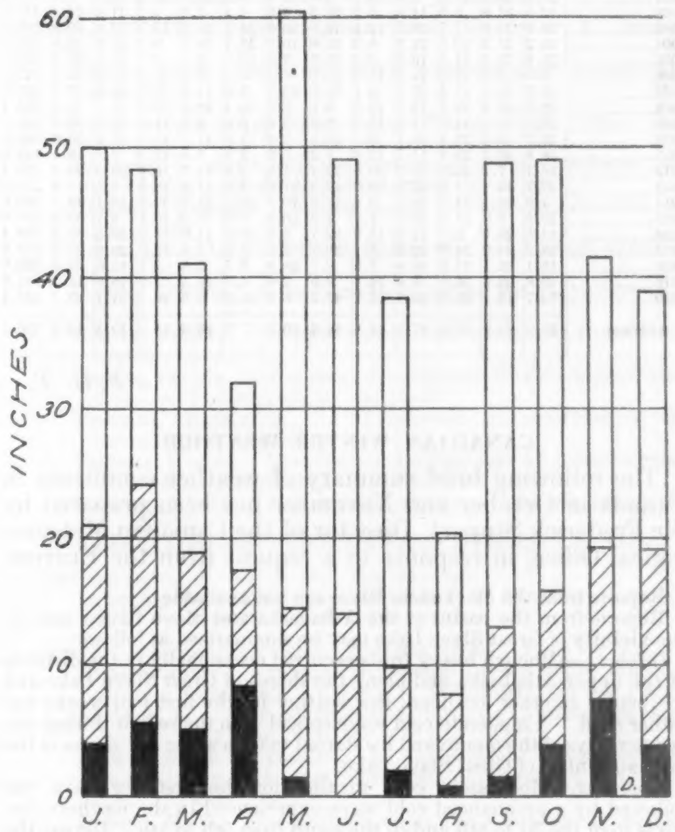


FIG. 1.—Rainfall at Pago Pago, Samoa. Highest, lowest, and average monthly amounts for years 1900-1920, inclusive.

works, Island Government, the Weather Bureau is able to present a table showing the monthly rainfall at Tutuila, Samoa, for the years 1900–1920, inclusive. The measurements were made at the United States Naval Station at Pago Pago Harbor.

A chart (Fig. 1) showing the highest, lowest, and average monthly amounts, adapted from a chart prepared by Lieut. Nyland, is also shown.

Tutuila is the southernmost island of the Samoan, or Navigator, group and is located in latitude 14° 18′ S., longitude 170° 42′ W. Pago Pago Harbor is on the south side of the island, some 85 miles east-southeast of Apia. Meteorological observations have been made at Apia for

many years and a chart (fig. 2) showing the average rainfall at that place is given in order that the amounts received at the two stations may be compared. Apia is situated on the north, or leeward, side of Upolu Island, the second largest island of the Samoan group.

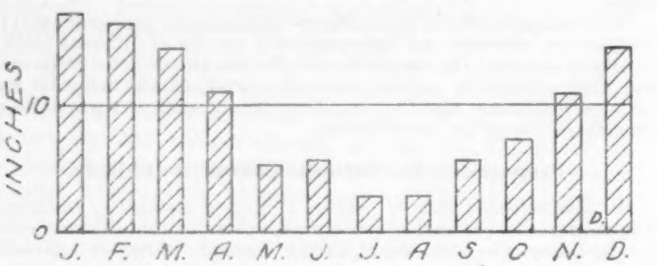


FIG. 2.—Rainfall at Apia, Samoa. Average monthly amounts.

Rainfall record, United States Naval Station, Pago Pago, Tutuila, 1900–1920.

[Inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1900	16.4	18.3	41.1	13.1	11.3	0.1	4.5	3.0	5.9	9.8	19.6	24.1	167.2
1901	21.5	29.0	17.1	9.4	15.1	3.5	10.4	6.2	21.6	21.2	18.4	3.9	177.3
1902	12.9	37.9	5.2	14.2	5.7	25.2	3.0	4.4	5.0	8.7	11.0	14.4	147.6
1903	21.9	24.9	12.7	26.0	12.1	12.5	16.6	11.2	10.3	19.9	20.4	10.8	199.3
1904	21.2	27.2	10.5	21.3	8.3	11.0	10.5	13.1	10.9	9.3	21.9	10.9	176.1
1905	21.8	12.1	15.5	16.0	3.5	10.3	7.5	10.6	1.7	8.7	12.3	10.1	130.1
1906	5.3	9.9	18.0	14.1	18.6	14.7	6.1	7.4	12.7	13.2	14.2	13.0	147.2
1907	19.2	21.2	11.3	26.1	13.1	32.0	12.5	5.0	11.1	23.7	29.0	17.9	222.1
1908	32.6	48.3	39.5	13.7	23.8	9.2	8.2	10.4	28.5	16.1	41.7	12.4	284.4
1909	16.1	15.1	11.6	13.8	15.5	9.8	3.6	3.6	8.1	11.8	19.9	16.2	145.1
1910	20.7	10.2	28.1	19.7	9.5	16.3	3.4	11.6	17.8	15.1	15.2	30.9	198.5
1911	18.8	30.2	19.3	11.7	12.3	5.2	5.2	2.3	5.0	12.3	9.4	18.1	149.8
1912	15.1	7.7	22.3	31.9	30.8	12.1	4.5	3.5	14.7	10.4	20.0	22.4	195.4
1913	27.7	44.7	17.8	25.5	60.5	12.5	21.8	5.4	17.2	18.6	7.5	16.0	275.2
1914	4.0	20.4	14.7	18.1	9.4	19.5	10.7	20.4	48.9	49.2	16.1	19.2	250.6
1915	37.5	7.9	17.6	10.7	1.7	4.5	16.4	0.6	10.0	10.1	8.7	30.6	156.3
1916	14.5	28.6	9.1	12.2	14.0	12.1	9.6	10.6	11.0	18.9	26.5	39.0	206.1
1917	38.3	34.6	34.0	22.2	5.4	20.7	7.5	5.8	7.8	19.5	29.8	24.3	249.9
1918	15.1	43.1	17.9	10.9	7.6	8.7	38.3	6.7	5.8	7.4	15.0	30.4	206.9
1919	49.8	22.6	16.5	8.4	14.8	9.6	2.0	4.7	11.3	3.9	16.9	14.4	174.9
1920	14.7	13.4	21.6	28.7	12.7	49.2	8.5	18.8	8.6	26.4	31.1	23.4	257.1
Average	21.2	24.2	19.1	17.5	14.6	14.2	10.0	7.9	13.0	15.9	19.3	19.2	196.1

—*F. G. T.*

CANADIAN WINTER WEATHER.

The following brief summary of weather conditions in Canada in October and November has been prepared by Sir Frederick Stupart, Director of the Canadian Meteorological Office, in response to a request from the EDITOR:

Reports from the Mackenzie River are not available.

Reports from the basins of the Athabaska and Slave Rivers and for the vicinity of Great Slave Lake may be summarized as follows:

October.—Although heavy frosts occurred occasionally in the districts of the upper Athabaska and along the shores of Great Slave Lake and frequently in other localities, the weather for the first four weeks was rather mild. A moderate cold wave spread into the region during the last few days of the month and ice started to form along the shores of the bays and inlets of Great Slave Lake.

November.—Moderately cold weather for the first few days was followed by a pronounced cold wave experienced in the northern districts from the 3d to 6th and in the south from 5th to 8th. During the cold dip minimum temperatures of zero or a few degrees below were registered in all localities reporting and the bays and inlets of Great Slave Lake were frozen over sufficiently for crossing by sleighs. The moderately cold weather following continued until the middle of the month when winter set in in earnest. Temperatures ranged from zero to 20 below during the last half of the month.

THE FORECASTING OF WINDS FOR AERIAL NAVIGATION.

Success in future aerial navigation will depend largely upon the forecasting of upper winds; but results to date have been surprisingly erroneous according to G. M. B. Dobson, in a paper presented before the Royal Meteorological Society (*Quarterly Journal Royal Meteorological Society*, October 1921, vol. 47, pp. 261–269). Investigating thoroughly, with forecasts based on the estimates of future pressure gradients, he has found primarily the Daily Weather Report inaccurate to a marked degree, but with more copious charts the results obtained would be only slightly improved. The inability to forecast, first, the general pressure distribution, second, the irregularities of pressure around cyclones and anticyclones, third, the unsettled pressure distribution without specified high-or-low-pressure centers, are considered some of the causes for such poor results. But the principle cause, and the one apparently responsible for most of the errors, is the lack of knowledge concerning the small irregularities of pressure distribution around the centers of low pressure. If this knowledge could be obtained perfectly, forecasts of wind directions could be determined with much certainty although the velocities would still be doubtful.

Although much credit was given Mr. Dobson by the attendant members of the Society for such exactness in his report, still his paper was not without criticism from Col. E. Gold, Sir Napier Shaw, Mr. J. S. Dines, and others who vigorously defended the intrinsic value of the synoptic charts.

He (Mr. Dobson) stated with emphasis that in all his studies utility was distinctly omitted, his experiments being chiefly for academic purposes; but, congruous to the ideas of L. H. Richardson, he contended that prior to bringing errors in pressure gradient forecasting to a minimum, maps of greater detail are absolutely essential.—*M. G. R.*

RADIO WEATHER REPORTS ON THE PACIFIC COAST.

In order to better serve the marine and aviation interests operating in the coastal waters of the Pacific and the States bordering the Pacific coast, a new program of broadcasting weather information will be undertaken by the Weather Bureau in cooperation with the Navy Department, beginning March 15, 1922. In addition to major bulletins, issued at noon and 10:30 p. m., 75th meridian time, from the San Francisco Naval Radio Station, there will be local bulletins issued at various times of day from the Naval Radio Stations at Tatoosh Island, Wash., North Head, Wash., Eureka, Calif., San Pedro, Calif., Dutch Harbor, Alaska, and Honolulu, Hawaii. The major bulletins from the San Francisco station are divided into two parts, the first giving surface data at 8 a. m. and 8 p. m. (75th meridian time) and upper-air data for the afternoon of the date of distribution; the second part contains a synopsis of general conditions, barometer readings at centers of HIGHS and LOWS, wind and weather forecasts, and flying weather forecasts for the areas concerned. The local bulletins refer to weather forecasts and storm warning and local weather at the station. The six stations issuing local reports may be called upon by ships at any time for the latest warnings or forecasts. Complete information concerning the new service is contained in a bulletin issued by the Forecast Division of the Weather Bureau under date of March 1, 1922. A new base map of the regions concerned has been prepared, and will be furnished free to vessel masters who regularly take and forward weather observations to the Weather Bureau or the Navy Hydrographic Office; to others they will be available at 75 cents per hundred.

It is of interest to note that this new program extends to the Pacific coast a type of service that has been recently put in operation along the Atlantic and Gulf coasts and in the Caribbean Sea. With the establishment of this service, the entire coast of the United States and the waters adjacent thereto will enjoy an equally complete system of weather reports.—*C. L. M.*

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JANUARY, 1922.

By HERBERT H. KIMBALL, Meteorologist.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48:225.

From Table 1 it is seen that direct solar radiation intensities averaged slightly above the normal for January at Washington, D. C., and Santa Fe, N. Mex., were close to normal at Madison, Wis., and decidedly below normal at Lincoln, Nebr.

Table 2 shows that the total solar and sky radiation received on a horizontal surface was generally above normal at Madison; at Washington there was a decided deficiency during the week beginning with January 15.

Skylight polarization measurements made on four days at Washington give a mean of 57 per cent, with a maximum of 62 per cent on the 25th. These are slightly below the average January Washington values. At Madison no measurements were obtained, as the ground was covered with snow during the entire month.

TABLE 1.—*Solar radiation intensities during January, 1922.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Washington, D. C.											
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Jan. 7	2.49						1.12	0.98	0.83		1.88
9	3.81			1.13			1.22	1.04			4.57
14	2.26	0.70	0.82	0.97	1.22		1.23	1.11	0.99	0.87	2.06
25	0.96	0.93	1.05	1.19	1.34	1.51	1.29				1.12
26	0.86	0.77	0.88	1.05	1.26	1.52	1.24	1.12			1.12
30	1.88				1.31		1.20	1.00	0.99	0.95	4.75
Means		**0.80**	**0.92**	**1.08**	**1.28**		**1.22**	**1.05**	**0.94**	**(0.91)**	
Departures		**+0.03**	**+0.04**	**+0.06**	**+0.05**		**−0.01**	**+0.01**	**+0.06**	**+0.11**	
Madison, Wis.											
Jan. 9	2.62	0.90	0.99	1.16				1.14	0.99		3.15
11	1.78	1.08						1.32	1.16		1.78
12	0.79		1.16								1.37
16	1.32			1.21	1.41			1.21			1.68
19	1.07			1.24	1.51						0.71
20	1.19	0.91	1.03	1.20	1.35	1.60					1.52
21	1.78		1.02	1.18							2.62
24	0.46	1.05	1.18	1.32	1.48	1.65					0.28
Means		**0.98**	**1.08**	**1.22**	**1.44**			**1.22**	**(1.08)**		
Departures		**+0.03**	**−0.01**	**−0.03**	**+0.07**			**−0.02**	**−0.04**		

TABLE 1.—*Solar radiation intensities during January, 1922*—Contd.

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Lincoln, Nebr.											
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Jan. 2	3.15	0.85	1.02	1.12				0.85	0.60	0.42	2.06
3	2.87		0.90	1.07		1.51					3.63
5	0.79	0.97	1.06	1.22							1.24
6	1.45		0.87	1.04				1.13	1.01	0.91	3.00
7	2.49	0.74	0.86	1.03	1.16	1.39					3.63
9	3.15	0.59	0.89	1.07				1.10	0.97		3.63
22	0.74	0.84	1.00	1.15			1.12	1.14	0.96	0.86	1.07
24	0.96		1.01	1.01							1.78
27	3.15			0.87	1.14		1.24		0.66	0.55	3.30
Means		**0.80**	**0.95**	**1.06**	**(1.15)**		**(1.18)**	**1.06**	**0.84**	**0.68**	
Departures		**−0.11**	**−0.08**	**−0.10**	**−0.20**		**−0.04**	**−0.13**	**−0.20**	**−0.25**	
Santa Fe, N. Mex.											
Jan. 10	2.62			1.34	1.55		1.50	1.38	1.24	1.28	3.15
11	2.16			1.36	1.48						2.16
12	1.68			1.31	1.55				1.26	1.23	1.68
13	1.60			1.34	1.51					1.17	2.36
21	1.32							1.44	1.33		1.68
Means				**1.34**	**1.52**		**(1.50)**	**(1.41)**	**1.28**	**1.23**	
Departures				**−0.04**	**+0.01**		**+0.02**	**+0.06**	**+0.05**	**+0.21**	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Jan. 1	167	134		+ 8	−11		+ 53	− 76	
8	184	175		+18	+20		+182	+ 62	
15	102	207		−73	+37		−331	+324	
22	191	215		+ 2	+26		−318	+504	

MEASUREMENTS OF THE SOLAR CONSTANT OR RADIATION AT CALMA, CHILE.

By C. G. ABBOT, Assistant Secretary.

[Smithsonian Institution, Washington.]

NOTE.—Owing to delay in transmission, the data from South America will be included in the next issue of the REVIEW.—EDITOR.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was slightly below the normal at land stations on the east coast of Newfoundland and in the south of England and Ireland, while the departures were small on the Atlantic and Gulf coasts of the United States, as well as in the Bermudas. The monthly average at Horta, Azores, was somewhat above the average, the unusually high barometric readings that prevailed from the 1st to the 21st being partially overcome by the period of low pressure during the last decade of the month.

Comparatively few fog reports were received from vessels, although fog was observed on 8 days at the 1 p. m. observation at stations on the British Isles.

January is normally the stormiest month of the year, and, taking it as a whole, the month under discussion lived up to its reputation, although the number of days on which winds of gale force were reported varied considerably in different sections of the ocean when compared to the normal as shown on the Pilot Chart.

On the 1st a HIGH with a crest of over 30.5 inches was over Kansas and strong northerly winds accompanied by comparatively high barometric readings prevailed in the western part of the Gulf of Mexico, as shown by following storm log:

American S. S. *Virginia:*

Gale began on the 1st, wind N. Lowest barometer 30.14 inches on the 1st, wind N., in latitude 24° 44′ N., longitude 96° 06′ W. End on the 1st, wind N. Highest force of wind 9, N.; shifts NNE.-N.

On the same day there was also a well-developed LOW over Nova Scotia, and, while at Greenwich mean noon of that day, light to moderate winds were the rule along the American coast, they increased in force later in the day, and by the morning of the 2d, that locality was swept by strong gales, the storm area extending as far east as the 60th meridian, between the 30th and 40th parallels. Storm logs follow:

American S. S. *El Mundo:*

January 1, fresh WNW. wind with barometer falling fast, overcast sky, rough sea; 7 p. m. position, 33° 32′ N., 76° 30′ W.
January 2, fresh NNW. gale, heavy swell from N., wind moderated during day; 7 p. m. position 36° 52′ N., 75° 33′ W.

American S. S. *Carrillo:*

January 1, strong winds with heavy rain squalls, wind veering from SW. to NW. Barometer fell to 29.7 inches at 4 p. m. Rough confused sea. 7 p. m. position, 33° N., 74° 07′ W.
January 2, moderate to fresh gales, rough sea, barometer unsteady, heavy snow squalls in a. m.; 7 p. m. position 34° 20′ N., 74° 33′ W.

British S. S. *Gloria de Larrinaga:*

Gale began on the 1st. Lowest barometer 29.15 inches at 2 p. m.; on the 2d, wind S., 10, in latitude 37° 32′ N., longitude 60° 20′ W. End on the 4th, wind NW. Highest force of wind, 10; shifts W.-NW.-W.

From the 2d to the 4th there was a disturbance of limited extent over the British Isles, as shown by following storm log from the American S. S. *Glenpool:*

Gale began on the 2d, wind WNW. Lowest barometer 29.15 inches at 4 a. m. on the 2d, wind WNW., 7, in latitude 58° 16′ N., 0° 40′ W. End on the 4th, wind N. Highest force of wind, 9; shifts NNE.-WNW.-NW.

The western disturbance moved slowly northeastward during the next 24 hours, and on the 3d was central near Sydney, Nova Scotia, the storm area now covering the region between the 30th and 45th parallels, and the 58th and 68th meridians. Southerly gales were also encountered by a few vessels near the 45th meridian, as shown by storm log from American S. S. *Noccalua:*

Gale began on the 3d. Lowest barometer 29.83 inches at 4 a. m. on the 4th, wind SSE., 8, in latitude 39° 40′ N., longitude 44° 50′ W. End on the 4th, SW. Highest force of wind 8, SSE.; Steady from SSE.

From the 4th to the 6th moderate weather prevailed over the entire ocean, except that on the latter date there was a LOW of limited extent near latitude 55° N., longitude 25° W. The easterly drift of this depression was slow, and moderate to strong gales prevailed until the 11th over the region between 30th meridian and the European coast. Storm logs follow:

American S. S. *Glenpool:*

Gale began on the 6th, wind SSW. Lowest barometer 28.67 inches at 2:30 a. m. on the 7th, wind SW., 8, in latitude 56° 10′ N., longitude 23° 48′ W. End on the 8th, wind WSW. Highest force of wind 8, WSW.; shifts SW.-WSW.-WNW.-WSW.

Danish S. S. *Arkansas:*

Gale began on the 8th, wind WSW. Lowest barometer 29.60 inches at 7 a. m. on the 8th, wind SW., in latitude 47° 57′ N., longitude 24° 30′ W. End on the 9th, wind NW. Highest force of wind 10, SW.; shifts SSW.-NW.

Danish S. S. *Frederick VIII:*

Gale began on the 9th, wind WSW. Lowest barometer 29.50 inches at 2 a. m. on the 11th, wind W., in latitude 57° N., longitude 21° 30′ W. End of gale on the 11th, wind NW. Highest force of wind 10; shifts WSW.-W.-NW.

On the 9th, Father Point, Quebec, was near the center of a LOW, and only moderate winds were reported at Greenwich mean noon by vessels between the 50th meridian and the American coast. Later in the day, however, and on the morning of the 10th, gales were encountered over a limited area. Storm logs:

British S. S. *Vasconia:*

Gale began on the 9th, wind S. Lowest barometer 29.10 inches at 11 p. m. on the 9th, wind S., 11, in latitude 42° 08′ N., longitude 56° 13′ W. End on the 10th, wind W. Highest force of wind 11, S.; shifts SSW.-SW.

British S. S. *Burgondier:*

Gale began on the 9th, wind S. Lowest barometer 29.60 inches at 8 p. m. on the 9th in latitude 41° N., longitude 55° 30′ W. End on the 10th, wind NW. Highest force of wind 10, SW.; shifts S.-SW.

On the 11th there was a well defined LOW central near Norfolk, Va., accompanied by strong gales along the coast between Hatteras and Charleston. This disturbance moved in a north-northeasterly direction, and on the 12th the center was near Father Point, Quebec; it then curved sharply toward the east, being central near St. Johns, N. F., on the 13th, and on that date southerly gales were encountered over a limited area between the 45th and 50th parallels and the 40th and 45th meridians. Storm logs follow:

American S. S. *Cody:*

Gale began on the 11th, wind SE. Lowest barometer 29.04 inches at 1 p. m. on the 11th, wind SW., in latitude 36° 05′ N, longitude 73° 10′ W. End on the 12th, wind NW. Highest force of wind 11; shifts SE-NW.

Belgian S. S. *Sunoco:*

Gale began on the 13th, wind S. Lowest barometer 29.78 inches at 7 p. m. on the 13th, wind SW., 9, in latitude 48° 25′ N., longitude 43° W. End on the 13th, wind W. Highest force of wind 10; shifts S-SW.

From the 15th to the 17th moderate winds were the rule over the western division of the ocean, while east of the 40th meridian heavy weather prevailed. Storm logs follow:

American S. S. *Finland:*

Gale began on the 15th. Lowest barometer 29.78 inches at 8 p. m. on the 15th, wind WNW., 8, in latitude 49° 36′ N., longitude 12° 40′ W. End on the 16th, wind NNW. Highest force of wind 9; hauled gradually to N.

Swedish S. S. *Stockholm:*

Gale began on the 15th, wind W. Lowest barometer 28.96 inches at 4 a. m. on the 16th, wind W., in latitude 58° 10′ N., longitude 20° 40′ W. End on the 17th, wind WSW. Highest force of wind 9; shifts WSW.-SW.-SSW.

French S. S. *La Lorraine:*

Gale began on the 16th, wind WSW. Lowest barometer 28.95 inches on the 19th, wind W., 9, in latitude 48° 20′ N., longitude 38° 20′ W. End on the 20th, wind N. Highest force of wind 12; shifts SW.-N.

Charts IX to XVI show the conditions from January 18 to 25, both inclusive. This was period of exceptionally heavy weather, and on several days storm areas covered the greater part of the ocean. It was during this period that the Norwegian steamer *Mod* was lost, and a large number of other casualties were also reported. Storm logs follow:

British S. S. *Valemore:*

Gale began on the 18th, wind S., 10. Lowest barometer 29.35 inches at 4 p. m. on the 18th, wind SW., 12, in latitude 39° 40′ N., longitude 64° W. End on the 19th, wind NW. Highest force of wind 12, SW.; shifts SW.-W.

Italian S. S. *Milazzo:*

Gale began on the 19th, wind SW. Lowest barometer 28.79 inches at 6 a. m. on the 19th, in latitude 41° 04′ N., longitude 43° 40′ W. End on the 19th, wind NW. Highest force of wind 11; shifts SW.-W.-NW.

British S. S. *Badagry:*

Gale began on the 19th, wind SW. Lowest barometer 28.94 inches at 4 a. m. on the 21st, wind SW., 11, in latitude 41° N., longitude 35° W. End on the 22d, wind NW. Highest force of wind 12; shifts SW.-NW.

American S. S. *Cliffwood:*

Gale began on the 19th, wind NW. Lowest barometer 29.27 inches at 5 p. m. on the 20th, wind SW., 8, in latitude 45° 10′ N., longitude 19° W. End on the 21st, wind W. Highest force of wind 10; shifts SW.-WNW.

Dutch S. S. *Eemdijk:*

Gale began on the 19th, wind SW., 6. Lowest barometer 28.96 inches on the 21st, wind W., 7, in latitude 46° 36′ N., longitude 20° 37′ W. End on the 22d, wind SSE., 7. Highest force of wind 11, SW.; shifts SW.-NW.

British S. S. *Bradford City:*

Gale began on the 21st, wind NNW. Lowest barometer 28.07 inches on the 21st at 3 p. m., wind NNW., 11, in latitude 48° 52′ N., longitude 36° 51′ W. End on the 22d, wind NNW. Highest force of wind 12; shifts NNW.-NE.-N.-NW. This gale was of force 11 throughout with squalls of hurricane force. The Norwegian steamer *Mod* foundered on the 22d near latitude 46° 17′ N., longitude 41° 10′ W.

Danish S. S. *Texas:*

Gale began on the 21st, wind SSW. Lowest barometer 28.79 inches at 6 p. m. on the 22d, wind S., in latitude 58° N., longitude 20° 05′ W. End on the 23d, wind SSW. Highest force of wind 12; shifts not given.

French S. S. *La Lorraine:*

Gale began on the 23d, wind WSW. Lowest barometer 29.71 inches on the 23d, wind W., 7, in latitude 42° 30′ N., longitude 60° 17′ W. End on the 24th wind NW. Highest force of wind 10; shifts W.-WNW.

Dutch S. S. *Rotterdam:*

Gale began on the 23d, wind WNW. Lowest barometer 28.96 inches at 4 p. m. on the 23d, wind NNW., 10, in latitude 45° 04′ N., longitude 44° 57′ W. End on the 27th, wind W. Highest force of wind 11; shifts WNW.-NW.

American S. S. *Montana:*

Gale began on the 23d. Lowest barometer 28.20 inches at 4 p. m. on the 24th, wind SW., 8, in latitude 48° 11′ N., longitude 34° 58′ W. End on the 26th, wind WSW. Highest force of wind 11, SW.; shifts not given.

British S. S. *Lapland:*

Gale began on the 24th, wind SE. Lowest barometer 28.26 inches at 1 a. m. on the 25th, wind W., 10, in latitude 48° 18′ N., longitude 33° 35′ W. End on the 25th, wind W. Highest force of wind 12; shifts SW.-W.-WNW.

American S. S. *Cliffwood:*

Gale began on the 24th, wind W. Lowest barometer 29.31 inches at 6 a. m. on the 24th, wind W., 10, in latitude 39° 25′ N., longitude 30° 30′ W. End on the 25th, wind WSW. Highest force of wind 12; shifts SW.-W.

On the 26th strong gales still prevailed over the middle sections of the ocean and northerly winds of gale force were also encountered off the coasts of Georgia and South Carolina. Storm logs:

American S. S. *West Nilus:*

25th moderate wind shifts from W. by N. to W. by S., force 3 to 7. Weather moderating, sea confused, rough and heavy. Westerly swell, barometer falling slowly from 29.19 to 28.79 inches. Greenwich mean moon position on the 26th, latitude 47° N., longitude 33° W.

American S. S. *William G. Warden:*

Gale began on the 26th, wind NE. Lowest barometer 29.52 inches on the 29th, wind NW., in latitude 30° 51′ N., longitude 79° 20′ W. End on the 30th, wind N. Highest force of wind 10, shifted three points.

By the 27th the disturbance that was near mid-ocean on the 26th, had moved eastward, the storm area having contracted somewhat, and westerly gales were encountered by vessels in the region between the 30th meridian and the European coast. Storm log:

American S. S. *W. H. Tilford:*

Gale began on the 26th, wind W. Lowest barometer 29.41 inches at 10.30 p. m. on the 26th, wind W., in latitude 44° 40′ N., longitude 12° 31′ W. End on the 29th, wind W. Highest force of wind 11, WSW.; shifts SW.W.

On the 28th there was a LOW central near latitude 47° N., longitude 40° W., with northerly gales in the westerly quadrants. Storm log:

British S. S. *Winnebago:*

Gale began on the 27th, wind NNW. Lowest barometer 28.84 inches at 4 p. m. on the 27th, wind WSW., 4, in latitude 48° 47′ N., longitude 45° 47′ W. End on the 29th NNW. Highest force of wind 9, NNW.; shifts S.-WSW.-NNW.

The depression off the American coast, near Hatteras, that was first reported on the 26th, seemed to take on a new lease of life, as on the 29th strong to moderate gales covered a limited area between the 30th and 40th parallels, west of the 68th meridian. This disturbance moved slowly eastward, increasing in extent and intensity, and by the 31st the storm area extended south to the 30th parallel and east to the 45th meridian. Storm logs:

Dutch S. S. *Maashaven:*

Gale began on the 28th, wind W. Lowest barometer 29.52 inches at 4 a. m. on the 29th, wind W., 9, in latitude 33° 23′ N., longitude 70° 55′ W. End on the 30th. Highest force of wind 10; shifts SW.-W.-NNW.

British S. S. *Badagry:*

Gale began on the 29th, wind ESE. Lowest barometer 29.10 inches at 8 p. m. on the 29th, wind E., 11, at latitude 39° 20′ N., longitude 59° W. End on the 30th, wind N. Highest force of wind 12; shifts ESE.-N.

American S. S. *Cliffwood:*

Gale began on the 30th, wind SW. Lowest barometer 29.48 inches at 2 p. m. on the 31st, wind SW., 12, in latitude 31° 32′ N., longitude 52° W. End on the 31st, wind NW. Highest force of wind 12, SW.; shifts SW.-W.

American S. S. *Independence Hall:*

Gale began on the 30th, wind N. Lowest barometer 29.20 inches at noon on the 30th, wind NW., 4, in latitude 35°48′ N., longitude 56° 39′ W. End on the 31st. Highest force of wind 10, N.; steady NW.

Swedish S. S. *Carlsholm:*

Gale began on 30th, wind NNE. Lowest barometer 28.82 inches at 4 p. m. on the 31st, wind N., 12, in latitude 45° 22′ N., longitude 50° 09′ W. End February 1, wind NNW. Highest force of wind 12, N.; steady NW.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

Judging from the reports that have been received from vessels the weather of the month over the North Pacific Ocean did not vary greatly from the average weather of January, differing in this respect from that of the North Atlantic Ocean, which was distinctly stormy. Most of the gales reported occurred west of the 155th meridian, W. longitude—85 per cent of those reported prior to the 26th. During the 26th–28th vessels between the Hawaiian Islands and the American coast experienced unusual northeast gales, due to the building up of a strong anticyclone to the northward.

Two vessels report having experienced winds of hurricane force. These were the American S. S. *West Jena*, Capt. J. A. Jacobson, Observer W. L. Doucett, Manila (Jan. 10), for San Pedro, and the British S. S. *Empress of Asia*, Capt. L. D. Douglas, R. N. R., Yokohama (Jan. 14), for Vancouver. The storm logs of these vessels are as follows:

West Jena.—Gale began on January 18 (eastern time) with wind at ENE. On the 19th the wind hauled slowly to S. and W., the barometer falling steadily. Lowest barometer, 29.41 inches, occurred at 6 a. m. on the 20th when in 35° 10′ N., 149° 50′ E., wind at that time SW. to W. Gale ended on 21st. Highest force, 12, W.

Empress of Asia.—Gale began early on 18th (eastern time) with wind at WNW. Lowest barometer, 29.11 inches, occurred at 4 a. m. same day in 46° 48′ N., 169° 14′ E., wind at the time being WNW., 7. Gale ended at 8 p. m. 18th. Highest force, 12, S. Wind backed from WNW. to S.

The American S. S. *Maui*, Capt. Peter Johnson, Honolulu (Jan. 26) for San Francisco, had very heavy weather for four of the five and one-half days of her voyage. For

the greater part of the time the decks were awash. Other vessels in the same area had a similar experience.

The month opened with the North Pacific anticyclone fairly well developed and occupying about its usual position. It remained nearly stationary until the 8th when there were indications of a movement eastward toward the continent. During this time a series of depressions from the western part of the ocean moved eastward across the Aleutian Islands and the Gulf of Alaska. During the passage of the disturbance of the 5th at Dutch Harbor the barometer at that place fell to 28.40 inches.

On the morning of the 10th the center of the anticyclone lay along the American coast, the central isobar being 30.50. Pressure was falling to the westward with the advance of a depression from the region of the Aleutians. By the 12th low pressure prevailed generally between the Hawaiian Islands and the mainland, being part of a system that extended thence westward to midocean.

This distribution continued until the 16th when pressure rose over the region to the eastward of the Hawaiian Islands and a fresh anticyclone was formed. This was immediately reinforced from the northward by an area of high pressure that had appeared over Alaska on the 13th. The area broke up, however, on the 19th the northern portion moving southeastward over the western United States while the southern portion remained over the ocean. During the several succeeding days the latter was reinforced from the westward and attained to very large proportions. On the 25th–27th it covered the entire ocean east of the 170th meridian, W., and north of the 20th parallel. On the 25th and 26th the American S. S. *Manukai*, about midway between Puget Sound and Honolulu, recorded a barometer of 30.68 inches. A vigorous depression formed to the westward of this anticyclone on the 28th and moved northward to Bering Sea. On the morning of the 31st the barometer at Dutch Harbor was 28.58 inches.

Pressure was almost continuously below normal at Dutch Harbor, the average for the month being some 29.48 inches, about 0.23 below normal. The lowest pressure reported, 28.40 occurred on the 5th, the highest, 30.28, on the 25th. At Honolulu pressure was somewhat above normal on the 4th–9th and 20th–27th and below on other days. The average for the month was practically normal, being approximately 30.01 inches. The highest reading, 30.12, occurred on the 21st–22d and the lowest, 29.82, on the 31st. At Midway Island pressure was mostly above normal, the average being 30.03 inches, or about +0.03. The only negative departure of consequence, amounting for the period to −0.19, occurred on the 11th–15th. The highest was 30.20 inches on the 21st–22d.

PACIFIC TYPHOON BETWEEN GUAM AND YAP DECEMBER 3 TO 9, 1921.

By José Coronas, S. J., Chief Meteorlogical Division.

(Weather Bureau, Manila, P. I., Dec. 29, 1921.)

Our observations of Guam gave the first signs of this typhoon on December 3 when it was probably formed not far from 145° E. and 10° N. On the 4th telegraphic reports received from Guam and Yap showed the center about halfway between the two stations moving apparently to WNW. or NW. by W. On the 5th and 6th the typhoon was practically to the west of Guam and north of Yap with a tendency to incline northward. Finally it recurved northeastward on the 7th and 8th, the center passing between the Ladrone and Bonin Islands during the night of the 8th–9th.

The winds in Guam veered from NE. to SE., S. and SW., while in Yap they backed first from NW. to W. and SW., and then they veered to WSW., and possibly to W., although the observations received so far are not complete.

The American steamer *Granite State* was well under the influence of this typhoon on December 6 to 8, on her way from Honolulu to Manila. The steamer was on these days between 145° and 135° E., 16° and 18° N.; the barometric minimum 746.75 mm. (29.40 inches) was observed between 2 and 3 a. m. of December 8, and a gale reported from SE., S. and SW. on the 7th and 8th.

Meteorological observations for Dec. 2 to 8, 1921.

Date and hour.	Guam. Pressure.[1]	Guam. Wind. Direction.	Guam. Wind. Force 0-12.	Guam. Weather.	Yap. Pressure.[1]	Yap. Wind. Direction.	Yap. Wind. Force 0-12.	Yap. Weather.
Dec. 2:	*mm.*				*mm.*			
6 a. m.	758.8	ne.	1	c.	....	....	....	....
2 p. m.	57.3	ne.	2	o.	....	....	....	....
Dec. 3:								
6 a. m.	57.0	ne.	4	r.	....	....	....	....
2 p. m.	54.3	ene.	5	o, q.	....	....	....	....
Dec. 4:								
6 a. m.	55.1	ese.	4	o, q.	755.2	nw.	3	c.
2 p. m.	54.7	ese.	4	p.	....	....	....	....
Dec. 5:								
6 a. m.	56.8	s.	1	p.	55.0	wsw.	3	c.
2 p. m.	55.2	se.	4	o, q.	55.4	w.	3	c.
Dec. 6:								
6 a. m.	56.0	sse.	3	r.	53.3	wsw.	5	c.
2 p. m.	55.4	sse.	3	p.	53.9	wsw.	5	o.
Dec. 7:								
6 a. m.	56.2	sse.	3	p.	54.7	sw.	3	b.
2 p. m.	55.5	se.	3	p.	54.4	wsw.	3	b.
Dec. 8:								
6 a. m.	56.6	s.	2	p.	56.1	sw.	2	c.
2 p. m.	56.2	ssw.	4	c.	55.7	wsw.	3	c.

[1] Gravity correction not applied.

ADDITIONAL NOTE ON THE WEST INDIAN HURRICANE OF SEPTEMBER 5–17, 1921.

The Weather Bureau recently received from the master of the Danish S. S. *Florida* a report of the weather experienced by that vessel on September 5-7, 1921, during a voyage from Philadelphia to Rio de Janeiro, which showed that the hurricane which passed over the Windward Islands on the night of September 8 was in existence as early as the 5th. The following extract has been taken from the report.

Position at noon of September 5, 13° 15′ N., 47° 36′ W., barometer 30.37.[1] wind SE., 2; sea SE., 2; 4 p. m., barometer 30.29, wind ENE., 2, sea ENE., 2; 8 p. m., barometer 30.28, wind ENE., 3, sea ENE., 3. At sunset the sky was very red and over the northeast horizon all was dark. The clouds observed comprised A. St., Fr. Nb., and Cu. Nb.; at this time the weather started to get squally.

At midnight of the 5th–6th the barometer was 30.29, wind NE., 4, sea NE., 4. At 4 a. m., barometer 30.17, wind ENE., 6, sea ENE., 6. At this time the same clouds were observed as at sunset on the preceding day but it was darkest over the northern horizon; 8 a. m., barometer 30.14, wind ENE., 6, sea ENE., 6. Noon, barometer 30.11, wind ENE., 8, sea ENE., 6. Position, 10° 10′ N., 45° 48′ W.

At 1 p. m. (6th) the wind suddenly turned to S., force 9; 4 p. m., barometer 30.11, wind S., 9, sea SE., 7, clouds, A. St. and Fr. Nb.; 8 p. m., barometer 30.23, wind SSW., 8, sea S., 7. Midnight, barometer 30.27, wind S., 6, sea S., 6, clouds Cu. Nb.; 4 a. m. (7th), barometer 30.23, wind S., 4, sea S., 4.

Had the *Florida* been equipped with wireless apparatus and able to send out reports of the hurricane the information would have been of great value, especially to the people of the Windward Islands, who had but very short notice of its approach.—*F. G. T.*

[1] The barometer evidently reads too high but no correction is available.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Canada.—Montreal, January 12.—Several thousand unemployed found work to-day clearing [snow from streets as a result of the] blizzard last night. Drifts were 8 feet deep in places.—*New York Herald, January 12, 1922.*

Newfoundland.—St. Johns, January 25.—A blizzard which has raged in Newfoundland for the last 24 hours, piling up huge drifts, and the intense cold have resulted in the closing of many harbors. * * * The steamer *Stella Maris*, caught in the ice in Bonne Bay, was held so fast that it was believed there was little chance of her being able to get out before spring.—*New York Herald, January 26, 1922.*

Portugal.—Lisbon, January 21.—More than 50 deaths and incalculable damage to shipping, in addition to the unroofing of houses and uprooting of trees, resulted from the storm which swept Portugal early in the week. Reports from the northern Provinces have only just been received, as they were delayed through the breaking of communications. Many ships were driven aground by the gale.—*Chicago Post, January 21, 1922.*

Italy.—The exceptional drought and its serious consequences are still the topic of the day in northern Italy, says the London *Times*. In the Trentino the water of a lake has fallen so much that a small island never seen before within living memory has appeared in the middle. From an inscription on a stone on this island, the people learn that a great drought occurred in 1806 and that in that year, too, the small island emerged from the water. Father Gaddoni, of Imola, says that one must go back to the year 1621 to find another drought in the Po Valley similar to the present one.—*New York Evening Mail, January 20, 1922.*

Russia.—Riga, January 25.—Navigation has been suspended in the Gulf of Riga on account of ice, and shipping has become exceedingly difficult in the port of Reval.—*New York Herald, January 26, 1922.*

China.—The Yellow River, which created such havoc last August, has once more deserted its bed, carrying destruction to 13 Provinces. So sudden was the rise that the inhabitants were not able to get out of the way; whole villages were washed down the river and thousands of people were drowned. Great tracts were flooded in Shantung, Kiansu, and Ahnwei. The submerged area was estimated at about 10,000 square miles.—*The Pathfinder, January 14, 1922.*

Hawaii.—An iceberg, said to have been exposed 200 feet in length and rising 10 feet out of the water, was seen by passengers of the steamship *Shinyo Maru*, 25 hours out of Honolulu, on January 10 * * *.

This is believed to be the first time an iceberg has been seen off the Hawaiian Islands.—*Evening Star, Washington, D. C., January 16, 1922.*

Panama.—Panama, January 4.—Torrential rains have flooded the River Tuira, in the Province of Darien, and the villages of Pinogana and Yavisa are inundated.—*Washington Post, January 5, 1922.*

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

The features which give individuality to the month were the persistence of anticyclones over the Great Basin region which seemed to be a point of concentration and of subsequent dispersion of anticyclones; uniformly high mean pressure in all parts of the country; irregular distribution of mean temperature and precipitation and at least three severe cyclonic storms, one of which No. IV of Chart III was the direct cause of much property loss along the middle Atlantic coast and No. XII which gave the remarkably heavy snow in the States of North Carolina, Virginia, Maryland, Delaware, the District of Columbia, and southeastern Pennsylvania.

The usual details follow.

CYCLONES AND ANTICYCLONES.

By W. P. DAY, Observer.

There was much similarity between the number and the predominating types of both HIGHS and LOWS in January as compared with December. The Plateau HIGH was persistent during much of the month. The unusual path of the Alberta HIGH of the 22d-31st which turned back on itself over Ontario was due to a reinforcement of pressure from the Hudson Bay region just as the Alberta HIGH was about to disintegrate. The two most severe storms of the month occurred off the middle Atlantic coast on the 11th and the 28th. The latter storm was halted off the Virginia Capes and turned at right angles to its previous path by the reinforcement of the previously mentioned HIGH (22d-31st).

Lows.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas	East Gulf.	South Atlantic.	Central.	Total.
January, 1922	8.0	1.0	2.0	......	3.0	1.0	1.0	1.0	......	17.0
Average number, 1892-1912, inclusive	4.7	2.5	0.9	0.4	1.4	1.5	0.4	0.4	0.5	12.7

Highs.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
January, 1922	3.0	1.0	5.0	......	......	9.0
Average number, 1892-1912, inclusive	0.8	0.6	5.5	1.7	0.4	9.0

FREE-AIR CONDITIONS.

By W. R. GREGG, Meteorologist.

Beginning with January, 1922, and monthly thereafter, there will appear in each number of the REVIEW a brief summary of the free-air conditions during that month, as observed by means of kites, balloons, airplanes, etc. The main purpose will be to discuss these conditions in relation to those at the surface and in relation to *normal* values at different levels—in effect, to present a review or survey of free-air conditions while they are still of current interest.

Table 1 gives for January the average values of temperature, relative humidity, and vapor pressure, together with departures from normal, and Table 2, resultant winds and normals, as determined from observations

with kites at the 6 primary aerological stations. Temperatures at all levels and at all 6 stations were not far from normal, there being a slight negative departure in all cases except above 1,000 meters at Groesbeck. Reference to Chart IV shows that temperatures at the surface were nearly normal in all parts of the country east of the Rockies, but that in the regions in which Broken Arrow, Drexel, and Ellendale are located there was a small positive departure. This discrepancy between Table 1 and Chart IV finds explanation in the fact that the aerological stations have been in operation for a comparatively brief period. The normals are therefore subject to some small revision as further observations are made, but this revision will almost certainly be less in the upper levels than near the surface.

The average temperature gradients are characteristic for this season of the year, except that at Groesbeck little change in temperature is shown from the surface to about 2,000 meters, whereas normally there is a decrease of about 4° C. At Ellendale there is the usual large winter inversion and at Drexel a moderate inversion. The other three stations show rather small lapse rates. Generally speaking, the largest inversions occurred during the coldest weather, but there were some exceptions. For example, at Ellendale on the 18th a moderate lapse rate was found above abnormally low temperatures at the surface. The free-air winds on this date were from the north—a very good illustration of the high correlation between free-air temperatures and winds—at any rate up to moderate heights in this country.

The lowest temperature, −26.2° C., was observed on the 15th at Ellendale at an altitude of 3,500 meters.

Relative humidity was generally somewhat above normal except at Royal Center and in the higher levels above Broken Arrow and Ellendale.

Variations in vapor pressure from the normal were similar to those in temperature, viz, negative except above 1,000 meters at Groesbeck.

Resultant winds were from a more southerly point and of lower speed than normal except at Groesbeck. At this station NNE. winds prevailed in the lower levels and WSW. in the upper, the north and south components respectively being much more pronounced than is normally the case. The unusual temperature departures, already referred to, seem to bear a very close relation to these abnormalities in resultant winds.

The daily observations at these kite stations and also at several pilot-balloon stations in different parts of the country show that, with few exceptions, free-air winds at altitudes of 2 kilometers and higher were from a westerly direction. This is the usual condition in winter, except in the extreme south and possibly along the Pacific coast. At Key West easterly winds were found from the 2d to 9th and from the 19th to 25th, in each period being due to high pressure central over the Southern States or off the south Atlantic coast. Farther north this type of pressure distribution seldom extends to any great height in winter because of the strong latitudinal temperature gradient. At Key West, however, the gradient is usually small. This was true particularly on the 4th and 5th and from the 20th to 23d when easterly winds prevailed up to altitudes of 7 to 10 kilometers, possibly higher.

The same general observation applies to the Pacific coast region where it is unusual to find a marked latitudinal temperature gradient, but where on the other hand the isotherms quite closely follow the coast line. As a result the anticyclonic and cyclonic systems extend as such to great heights and the wind directions at the surface and in the free air are not greatly different. At San Francisco easterly winds were observed in the upper levels from the 8th to 12th and from the 19th to 23d; and at San Diego from the 10th to 13th and on the 23d and 24th.

In other parts of the country, as already stated, free-air winds were prevailingly from a westerly direction, i. e., SSW. to NNW., mostly between SW. and NW., the usual condition in winter. A notable exception occurred from January 26 to 30, when easterly winds were observed at heights of 3 to 7 kilometers over nearly all of the country east of the Rocky Mountains. During this period a large and well-developed anticyclone was central over the lower Lakes and the St. Lawrence Valley. When it first appeared in North Dakota on the 22d, and from then until the 24th, while it was moving eastward, it was attended by very low temperatures, with the result that there was a strong gradient of temperature from south to north. Hence, the winds a short distance above the surface, irrespective of their direction at the latter, were westerly. From the 25th to the 30th, however, the anticyclone was practically stationary in position and diminished somewhat in intensity, the temperatures in its northern and central portions meanwhile moderating considerably. The resulting temperature gradient from south to north was small, amounting to only 20° to 30° F. from the upper Lakes to the Gulf on the 27th, not enough to cause a reversal of pressure gradient in the free air below heights of 4 to 7 kilometers.

This occurrence is a very good example of the intimate relation between free-air winds and surface temperature distribution, the latter being far more influential than the sea level *pressure* distribution. This relation may be expressed thus: (*a*) If the temperature is fairly uniform over wide areas, the free-air winds conform closely to the surface isobars and show that anticyclones and cyclones extend as such to great altitudes; (*b*) if, on the other hand, the latitudinal temperature gradients are steep at the surface and also, though to a less extent, in the higher levels, then the free-air winds very quickly show decided shifts from those at the surface; in other words, the surface pressure systems lose their identity at a very low altitude, the isobars opening out on the north side of cyclones and on the south side of anticyclones, and at still higher levels becoming practically parallel over wide areas.

During this period of easterly free-air winds a fairly active cyclone formed over the Florida Peninsula and moved slowly north-northeastward along the Atlantic coast. By the morning of the 28th it had reached the Virginia capes, and during that day there was heavy snowfall over Virginia, North Carolina, Maryland, and the District of Columbia. This was a typical "coast storm." It seems likely that the intensity of such storms, so far as precipitation is concerned, is intimately related to the depth of the easterly winds to the north and northwest of them. These cause a tremendous uplift of the warmer air which they underrun and a consequent condensation of large masses of water vapor.

TABLE 1.—*Free-air temperatures, relative humidities and vapor pressures during January, 1922.*

TEMPERATURE (°C).

Altitude. M. S. L. (*m*).	Broken Arrow, Okla. (233*m*.). Mean.	Departure from normal.	Drexel, Nebr. (396*m*.). Mean.	Departure from normal.	Due West, S.C. (217*m*.). Mean.	Departure from normal.	Ellendale, N. Dak. (444*m*.). Mean.	Departure from normal.	Groesbeck, Tex. (141*m*.). Mean.	Departure from normal.	Royal Center, Ind. (225*m*.). Mean.	Departure from normal.
Surface	2.2	−2.1	−7.1	−1.1	6.3	......	−12.2	−2.3	5.6	−3.2	−5.8	−2.7
250	2.2	−2.1	......	......	6.1	......	......	......	5.2	−3.2	−5.8	−2.6
500	1.5	−2.3	−7.3	−1.2	4.6	......	−11.9	−2.0	4.5	−2.9	−6.2	−1.9
750	0.9	−2.7	−6.8	−0.9	4.1	......	−10.4	−0.8	4.9	−2.2	−6.2	−1.5
1,000	0.7	−3.0	−6.3	−1.4	3.6	......	−9.1	−1.0	6.4	−0.7	−6.5	−1.8
1,250	0.8	−2.9	−5.9	−1.6	3.0	......	−8.5	−1.3	7.1	+0.5	−6.6	−1.8
1,500	0.7	−2.5	−6.0	−1.7	2.3	......	−8.9	−1.6	7.0	+1.2	−7.0	−2.0
2,000	−0.2	−1.8	−7.6	−2.3	0.7	......	−10.6	−1.5	5.5	+1.3	−7.4	−1.7
2,500	−2.1	−2.1	−9.7	−2.4	−1.1	......	−12.3	−1.0	2.8	+0.8	−9.6	−2.6
3,000	−4.4	−1.8	−11.6	−1.9	−3.1	......	−15.1	−1.1	0.5	+0.8	−11.6	−2.3
3,500	−6.5	−1.7	−14.6	−2.6	−5.1	......	−18.2	−1.4	−1.9	+1.0	−13.8	−2.1
4,000	−9.0	−2.9	−17.9	−3.3	−7.3	......	......	......	−4.3	+1.4	......	......
4,500	−12.1	......	−21.7	−4.3	−10.1	......	......	......	−7.9	+0.4	......	......
5,000	−15.1	......	−24.7	......	−12.6	......	......	......	−11.9	−0.2	......	......

RELATIVE HUMIDITY (%).

Altitude. M. S. L. (*m*).	Broken Arrow, Okla. (233*m*.). Mean.	Departure from normal.	Drexel, Nebr. (396*m*.). Mean.	Departure from normal.	Due West, S. C. (217*m*.). Mean.	Departure from normal.	Ellendale, N. Dak. (444*m*.). Mean.	Departure from normal.	Groesbeck, Tex. (141*m*.). Mean.	Departure from normal.	Royal Center, Ind. (225*m*.). Mean.	Departure from normal.
Surface	72	−3	82	0	68	......	86	+7	78	−1	70	−10
250	72	−2	......	......	68	......	......	......	77	0	70	−9
500	68	+2	81	+2	67	......	84	+6	75	0	61	−14
750	64	+4	76	+3	65	......	76	+4	73	+3	57	−13
1,000	59	+5	73	+6	65	......	70	+6	67	+5	55	−9
1,250	54	+4	69	+8	65	......	65	+6	61	+4	52	−6
1,500	50	+3	64	+6	67	......	63	+6	58	+5	50	−3
2,000	46	+4	60	+4	62	......	57	0	55	+9	42	−5
2,500	42	0	58	+3	64	......	53	−4	58	+16	45	0
3,000	34	−11	57	+1	62	......	53	−4	56	+17	46	−2
3,500	32	−22	60	+6	61	......	54	−3	51	+13	43	−10
4,000	30	−11	66	+14	59	......	......	......	44	+8	......	......
4,500	30	......	69	+16	59	......	......	......	43	+9	......	......
5,000	30	......	68	......	60	......	......	......	42	......	......	......

VAPOR PRESSURE (*mb*.).

Altitude. M. S. L. (*m*).	Broken Arrow, Okla. (233*m*.). Mean.	Departure from normal.	Drexel, Nebr. (396*m*.). Mean.	Departure from normal.	Due West, S. C. (217*m*.). Mean.	Departure from normal.	Ellendale, N. Dak. (444*m*.). Mean.	Departure from normal.	Groesbeck, Tex. (141*m*.). Mean.	Departure from normal.	Royal Center, Ind. (225*m*.). Mean.	Departure from normal.
Surface	5.53	−1.08	2.93	−0.51	7.25	......	2.23	−0.31	7.65	−1.89	2.91	−1.38
250	5.51	−1.03	......	......	7.12	......	......	......	7.38	−1.59	2.85	−1.31
500	5.01	−0.60	2.82	−0.44	6.34	......	2.20	−0.30	6.81	−1.45	2.55	−1.11
750	4.54	−0.45	2.77	−0.13	6.16	......	2.14	−0.15	6.75	−0.73	2.39	−0.93
1,000	4.04	−0.39	2.74	0.00	5.96	......	2.09	−0.13	6.69	+0.21	2.23	−0.67
1,250	3.65	−0.38	2.63	+0.06	5.50	......	1.97	−0.20	6.36	+0.66	2.10	−0.57
1,500	3.26	−0.36	2.44	+0.01	5.18	......	1.85	−0.18	6.04	+1.05	1.98	−0.39
2,000	2.75	−0.14	2.02	−0.14	4.45	......	1.52	−0.27	5.17	+1.29	1.64	−0.31
2,500	2.23	−0.59	1.64	−0.21	4.03	......	1.29	−0.14	4.61	+1.55	1.53	−0.14
3,000	1.61	−0.99	1.39	−0.18	3.48	......	1.07	−0.02	3.78	+1.30	1.28	−0.24
3,500	1.42	−1.19	1.19	−0.11	3.04	......	0.97	+0.15	3.01	+0.91	1.07	−0.20
4,000	1.28	−0.65	1.01	−0.04	2.74	......	......	......	2.32	+0.56	......	......
4,500	1.18	......	0.64	−0.29	2.59	......	......	......	2.09	+0.43	......	......
5,000	1.10	......	0.31	......	2.48	......	......	......	1.88	......	......	......

TABLE 2.—*Free-air resultant winds (m. p. s.) during January, 1922.*

Altitude. M. S. L. (*m*.)	Broken Arrow, Okla. (233*m*.) Mean. Dir.	Vel.	Normal. Dir.	Vel.	Drexel, Nebr. (396*m*.) Mean. Dir.	Vel.	Normal. Dir.	Vel.	Due West, S.C. (217*m*.) Mean. Dir.	Vel.	Ellendale, N. Dak. (444*m*.) Mean. Dir.	Vel.	Normal. Dir.	Vel.	Groesbeck, Tex. (141*m*.) Mean. Dir.	Vel.	Normal. Dir.	Vel.	Royal Center, Ind. (225*m*.) Mean. Dir.	Vel.	Normal. Dir.	Vel.
Surface	N. 88° W.	0.3	S. 33° W.	0.8	S. 59° W.	0.9	N. 82° W.	1.6	N. 17° W.	0.5	N. 80° W.	2.7	N. 54° W.	3.3	N. 22° E.	2.3	N. 30° W.	0.9	S. 57° W.	1.7	S. 50° W.	2.3
250	S. 50° W.	0.4	S. 30° W.	1.2	......	......	......	......	N. 34° W.	0.7	......	......	......	......	N. 24° E.	3.0	N. 41° W.	0.9	S. 69° W.	2.1	S. 46° W.	2.8
500	S. 16° E.	2.1	S. 34° W.	2.2	S. 55° W.	1.7	N. 76° W.	2.7	N. 73° W.	1.6	N. 87° W.	3.0	N. 55° W.	3.9	N. 30° E.	3.0	S. 83° W.	1.4	S. 52° W.	3.4	S. 60° W.	5.0
750	S. 8° E.	2.9	S. 36° W.	3.3	S. 73° W.	3.5	N. 69° W.	4.6	W.	3.0	N. 87° W.	4.1	N. 59° W.	6.1	N. 33° E.	2.0	S. 75° W.	2.6	S. 65° W.	4.4	S. 67° W.	7.3
1,000	S.	3.5	S. 57° W.	3.8	S. 75° W.	4.0	N. 71° W.	5.8	S. 87° W.	3.7	N. 76° W.	4.8	N. 59° W.	11.0	N. 16° E.	0.6	S. 74° W.	3.4	S. 87° W.	6.5	S. 73° W.	7.8
1,250	S. 19° W.	3.6	S. 70° W.	4.0	S. 79° W.	6.1	N. 70° W.	7.0	S. 77° W.	6.0	N. 75° W.	6.1	N. 62° W.	8.6	N. 83° W.	2.0	S. 80° W.	4.4	N. 86° W.	7.8	S. 77° W.	9.3
1,500	S. 31° W.	3.6	S. 57° W.	6.3	S. 83° W.	7.2	N. 69° W.	8.2	S. 82° W.	6.9	N. 81° W.	5.9	N. 59° W.	9.1	S. 80° W.	3.6	S. 88° W.	5.6	N. 75° W.	9.7	S. 80° W.	10.4
2,000	S. 64° W.	5.2	S. 66° W.	9.1	S. 88° W.	8.9	N. 70° W.	10.6	N. 89° W.	8.5	N. 79° W.	7.7	N. 62° W.	11.2	S. 74° W.	8.1	S. 88° W.	6.5	N. 79° W.	10.8	S. 82° W.	12.4
2,500	S. 74° W.	7.4	S. 83° W.	9.8	N. 88° W.	11.1	N. 78° W.	12.6	N. 80° W.	12.1	N. 76° W.	9.9	N. 62° W.	13.2	S. 66° W.	11.6	W.	7.4	S. 87° W.	13.4	W.	14.3
3,000	S. 78° W.	10.1	N. 80° W.	12.3	S. 89° W.	13.1	N. 76° W.	14.4	N. 78° W.	17.1	N. 74° W.	13.3	N. 65° W.	14.6	S. 66° W.	13.9	N. 89° W.	9.0	S. 86° W.	12.5	N. 88° W.	14.3
3,500	S. 87° W.	9.9	N. 71° W.	14.0	N. 79° W.	14.5	N. 77° W.	15.5	N. 83° W.	17.3	N. 74° W.	12.3	N. 65° W.	16.2	S. 72° W.	13.2	N. 78° W.	11.0	N. 74° W.	16.6	S. 71° W.	12.8
4,000	S. 68° W.	15.0	N. 68° W.	19.3	N. 86° W.	16.7	N. 84° W.	17.2	N. 69° W.	16.9	N. 54° W.	17.6	N. 59° W.	17.8	S. 46° W.	16.7	N. 63° W.	11.8	......	......	S. 63° W.	17.3
4,500	S. 68° W.	16.3	......	......	N. 56° W.	12.9	N. 84° W.	18.8	N. 45° W.	17.6	......	......	N. 49° W.	19.1	S. 54° W.	18.5	N. 44° W.	9.2	......	......	......	......
5,000	W.	17.6	......	......	W.	15.0	W.	18.9	N. 45° W.	17.8	......	......	N. 76° W.	17.3	S. 68° W.	21.6	W.	13.0	......	......	......	......

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

(Weather Bureau, Washington, D. C.)

PRESSURE AND WINDS.

Probably the most important feature of the atmospheric pressure distribution for the month was the persistence and strength of the Plateau high area. Save for a few days at the beginning of the month, a short period slightly after the middle, and again toward the end, the pressure over this region was continually high. At Baker City, Oreg., the sea-level pressure on the 11th, 31.02 inches, was the highest ever observed at that station.

For the month as a whole pressure was above normal over all portions of the United States, save in a small section of the far Southwest, where there was a slight deficiency. In the Canadian Provinces average pressures were likewise above normal over the central and eastern districts, but over the western Provinces there was a tendency toward slight deficiencies.

Compared with the previous month, pressure was higher in all districts, save in the Rocky Mountains and portions of the adjacent Great Plains.

From the middle and upper Mississippi Valley eastward the increases over the preceding month were important, ranging from 0.10 to 0.20 inch. In other districts the variations were distinctly less.

In the Plateau districts there was a general movement of the winds at the lower levels outward in all directions from the region of highest pressure, over southern Idaho and portions of adjacent States. In other districts wind directions varied greatly. Over the Atlantic and Gulf States and in portions of the Ohio Valley the winds were mainly from north or northeast points. In the middle Plains and portions of the Lake region they were largely from the south; elsewhere variable.

High winds over extensive areas were confined mainly to a few periods; over the Great Lakes and portions of adjacent territory they occurred on the 4th and 5th; over the Atlantic Coast States they occurred mainly on the 11th and 12th, reaching a velocity of 74 miles an hour at Eastport, Me., and Atlantic City, N. J.; and again on the 22d in the Lake region, reaching a velocity of 76 miles per hour at Buffalo, N. Y.

TEMPERATURE.

The persistent cold over the Plateau region and the adjacent portions of the Pacific Coast States was the most important feature of the temperature distribution during the month. In the central portion of this region the daily temperatures were below normal throughout the entire month, save for a day or two, and the minimum temperatures, and monthly means as well, were the lowest of record for January. Frosts were frequent in central and southern California and the adjacent portions of Arizona, attaining their maximum severity at the beginning of the third decade, when much damage to citrus fruits and winter gardens was reported.

In the districts from the Rocky Mountains eastward there were frequent and important changes in temperature, but no unusual extremes were observed. The principal periods of cold were as follows: Over the Gulf States on the 2d; in the southern Appalachian Mountains and Middle Atlantic States on 13th and 14th; over Texas and the Southwest on the 19th to 21st; from the middle Mississippi Valley northeastward to New England on the 23d to 26th; and in the Middle Plains region on the 30th.

Minimum temperatures below freezing were observed in some portion of all the States, and temperatures below zero occurred as far south as North Carolina, Tennessee, Oklahoma, northern Texas, and thence westward. The lowest reported, $-54°$, occurred in northern Wisconsin, and temperatures of $-50°$ or lower were reported also from northern Minnesota and the mountain regions of Idaho and Wyoming.

The highest temperatures of the month were observed in the central valleys and most northern and eastern districts during the first few days, over the Pacific Coast States about the 10th to 14th, and in the Gulf and South Atlantic States about the 19th to 21st.

For the month as a whole, temperatures were below normal in all districts west of the Rocky Mountains, the deficiencies ranging from eight to fourteen degrees in the central Plateau. Monthly averages were also below normal by small amounts from Texas northeastward to the Ohio Valley and over much of the Atlantic coast area.

Mean temperatures for the month were slightly above normal in the Middle Gulf States and Tennessee Valley, from the Middle Plains northward, and generally over Canada, the month being distinctly warm on the average in the Canadian Northwest.

PRECIPITATION.

The principal periods when precipitation was general and of importance over large areas were as follows: From the 2d to 5th, during which time a storm of wide extent moved from the far Southwest to New England. Heavy rains from this storm prevailed over southern California and portions of Arizona, turning into snow at the higher elevations of the southern Mountain districts. It was attended by light rains or snows in the Great Plains, and by moderate to heavy rains or snows in the central valleys and eastern districts. On the 10th to 12th precipitation was general over Texas and other portions of the Southwest, and generally from the Mississippi River to the Atlantic coast. Heavy rains occurred over the Gulf and South Atlantic States, and heavy rains near the coast and heavy snows further inland to the northward. From the 26th to 29th, a storm of considerable importance moved from southern Florida northeastward slightly off the Atlantic coast line, giving moderate rains in the southern areas, sleet in portions of Georgia and South Carolina and heavy snow from North Carolina to the eastern portions of Pennsylvania, New York, and southern New England.

The total precipitation for the month was generous over the Gulf and Atlantic Coast States, and in the Ohio and lower Mississippi Valleys, although in the last-named districts the monthly amounts were less than normal. The precipitation was usually light over the northern districts east of the Rocky Mountains, and over the Pacific coast and northern Plateau States there was a well marked deficiency. In southern California the precipitation was unusually heavy, occurring mainly near the beginning and end of the month.

SNOWFALL.

The area over which measurable snow occurred embraced the greater part of the country, and the total fall for the month was equal to or in excess of the average over many sections.

The snow over the Middle Atlantic States during the 27th to 29th was in many sections the heaviest single fall of record, this being particularly true from central North Carolina northeastward through the central portions of Virginia and Maryland to southeastern Pennsylvania where the unmelted depths ranged from 15 to 30 inches or more. A full account of this unusual snowfall appears in another portion of this REVIEW. (See pp. — to —.)

In the western Mountain regions snowfall was deficient in the Sierra Nevada, and generally over Arizona and New Mexico, but in other portions the amounts were usually near the normal fall, and the outlook was favorable for a plentiful supply of water for irrigation and other purposes.

RELATIVE HUMIDITY.

The distribution of moisture in the atmosphere as indicated by the average relative humidity presented no unusual features.

In general the departures from normal coincided with the distribution of precipitation. In the South Atlantic and Gulf States the relative humidity was usually above normal, although there were some well marked exceptions. Likewise in much of the Great Plains, Rocky Mountains, and Plateau regions there was a general excess. Over the remaining districts the average relative humidity was less than normal, the negative departures being well pronounced over limited areas in the upper Mississippi Valley, the Great Lakes region, and eastward.

The deficiency over the Pacific Coast States was likewise pronounced in several instances.

STORMS AND WEATHER WARNINGS.

By EDWARD H. BOWIE, Supervising Forecaster.

WASHINGTON FORECAST DISTRICT.

At the beginning of the year a disturbance of considerable intensity moved eastward across the northern States and passed to Newfoundland, followed by strong west and northwest winds and gales along the middle Atlantic and New England coasts and by a cold wave on the 2d in the North Atlantic States. Storm warnings in connection with this disturbance were ordered on the last day of the preceding month and on the same day cold-wave warnings were ordered along the extreme northeast border. On the 3d the pressure was low over the far west and southwest and on the morning of the 4th a disturbance of marked intensity had its center over northwest Missouri. Moving thence this disturbance crossed the Great Lakes and moved down the St. Lawrence Valley, attended by gales and snow and rain in the region of the Great Lakes, snows and rain in New York and New England, and general rains elsewhere east of the Mississippi River. This disturbance was followed by much colder weather over the western half of the Washington Forecast District, warning of which was issued well in advance of its occurrence. Also on the night of the 4th southwest storm warnings were ordered for the Atlantic coast at and north of the Virginia Capes, but as the storm diminished in intensity after passing the region of the Great Lakes the winds on the Atlantic coast did not exceed in speed the scale of "strong."

On the morning of the 9th a disturbance made its appearance over northwestern Mexico, the lowest reading being to the southward of El Paso at this time. This disturbance was evidently already well organized, for at the following observation it was over Texas with a marked depression of the barometer at its center. Moving thence in an east-northeast direction the center of this storm advanced rapidly and the evening of the 10th it was over northern Alabama. When over the West Gulf States, storm warnings were displayed on the middle Gulf coast and forecasts of general rains and snows over the States east of the Mississippi River, and at the time the storm was central over northern Alabama storm warnings were extended to the southwest Florida coast and on the Atlantic coast from Key West, Fla., to Boston, Mass. During the night of the 10th the course of the storm was more to the northeast and on the morning of the 11th the center of the storm was over southeastern Virginia with the lowest barometer reading 28.98 inches at Cape Henry. Then the center passed directly north-northeastward and the evening of the 11th its center was in the vicinity of New York City. Whole-gale warnings were displayed the morning of the 11th on the Atlantic coast at and north of the Virginia Capes and warnings of heavy snows were issued for the Atlantic States north of Maryland. This disturbance was the severest thus far of the season along the Atlantic coast, but fortunately the destruction of shipping was minimized because of the timeliness of the warnings. There were heavy snows during the 11th generally throughout the New England and Middle Atlantic States, except on the immediate middle Atlantic and southern New England coasts, where snow changed to rain.

There was much delay in communication and transportation in the area of heavy snow and heavy snow and rain. Following this disturbance much colder weather overspread the Middle West and the Eastern and Southern States with frosts as far south as Miami, Fla., and a cold wave in extreme northern New York and northern New England. A feature of the weather during the first half of January was the persistence of the winter HIGH over the western Plateau region. This continued until the 16th when after a pronounced rise in pressure over the Alaska area the HIGH gradually gave way and was followed by an extensive area of low pressure on this date, which gave rains and snows on the Pacific Slope. At the same time, an extensive area of high pressure and much colder weather appeared over the western Canadian Provinces. The LOW over the western Plateau was central the morning of the 17th over southeastern Idaho and at that time general snows were falling over the northern Plateau and northern Rocky Mountain regions and rains on the Pacific coast. Moving southeastward, this disturbance was central the morning of the 18th over Arizona, and during the 18th the pressure fell over the Mississippi Valley and the western Canadian Provinces. Nothing important in the way of cyclonic developments took place during the 19th to 20th, but on the 21st a disturbance advanced rapidly out of the far Northwest and passed thence along the northern border, followed by a pronounced cold wave, warnings of which were issued well in advance of its occurrence. As this disturbance passed eastward from the Great Lakes it gained greatly in intensity and required the display of storm warnings on the north Atlantic coast. The pressure remained high over the eastern half of the country several days following, nevertheless, conditions remained unsettled in the South and rain, sleet and snow fell in the South Atlantic and Gulf States, and on the 26th a disturbance was indicated over southern Florida. This disturbance moved northward along the coast and the evening of that date storm warnings were displayed on the Virginia and North Carolina coasts. On the morning of the 27th when the center of this disturbance was off the South Carolina coast the display of storm warnings was extended northward and eventually to the whole of the New England coast and forecasts of snow made the previous day were repeated for the Middle Atlantic and New England States. The storm under consideration gave severe gales on the middle Atlantic and southern New England coasts and heavy falls of snow in the Middle Atlantic States and extreme southern New England, and heavy falls of rain, sleet, and snow in the Carolinas and Georgia. The fall of snow was exceptionally heavy in Virginia, the District of Columbia, Maryland, Delaware, eastern Pennsylvania, New Jersey, and extreme southern New York.

Warnings of frosts for the Southern States and of cold waves were issued on a number of days during the month.

CHICAGO FORECAST DISTRICT.

The first cold wave warnings of the month were issued during the period from the 2d to the 4th, inclusive. for that portion of the district from eastern Montana eastward to Minnesota, thence southward and southeastward over the western Lake region and the middle Mississippi and lower Missouri Valleys. No warnings were then necessary until the 17th when a depression centered that morning over the Plateau region, in its eastward movement, was followed by

an area of high pressure, bringing much colder weather progressively over most of the district during the 18th and 19th. In connection with this disturbance stock warnings were issued on the 17th for South Dakota, Nebraska, and Wyoming, and on the 18th for Kansas.

On the morning of the 21st a low pressure area of moderate intensity was centered over southern North Dakota and, during the ensuing 24 hours, moved rapidly eastward, followed by the coldest weather of the present winter thus far. Minima of 40° to 50° below zero were registered on the 22d in Manitoba and Saskatchewan and 30° to 40° below in North Dakota and northern Minnesota, the line of zero temperature reaching southward as far as central Illinois and the northern portions of Kansas and Missouri. This severe cold was preceded by warnings issued on the 21st for most of the district from the Rockies eastward to Lake Michigan and Illinois. Stock advices were also sent to South Dakota.

On the evening of the 27th, as it was apparent that an area of high pressure would soon appear over the northwest, cold-wave warnings were issued for Montana, northern Wyoming, North Dakota, and western South Dakota, these warnings being repeated on the morning of the 28th. During the 28th the high-pressure area developed and moved slowly southward, being blocked in its advance by an immense field of high barometer over Ontario. On the 29th and 30th the warnings were extended eastward to include western Minnesota, Nebraska, eastern Kansas, western Iowa, and northwest Missouri. On the 28th and 31st stock advices were telegraphed to points in the Dakotas, Wyoming, and Nebraska.

Cold-wave warnings were ordered from the evening map of the 31st for eastern and central South Dakota, western Nebraska and extreme southeastern Wyoming.—*E. H. Haines.*

NEW ORLEANS FORECAST DISTRICT.

Northwest storm warnings were ordered displayed on the Texas coast at 1 p. m. on the 10th because of an eastward-moving disturbance over the lower Mississippi Valley, which was followed by moderate gales that afternoon and night. Small-craft warnings were displayed on the Louisiana coast. The wind continued strong at Galveston, Tex., throughout the 11th. The area of high pressure in the rear of the disturbance extended well to the southward over the Rio Grande Valley and northeastern Mexico on the morning of the 12th and was attended by gales on the coast of Mexico. "Norther" warnings were issued at 8 p. m. on the 11th for Tampico and Progreso, Mexico.

Small-craft warnings were displayed on the Texas coast on the 16th and were justified.

Northwest storm warnings were ordered displayed from Morgan City, La., to Brownsville, Tex., at 8:20 p. m. on the 18th and were extended over the Louisiana coast east of Morgan City the following morning. The warnings were justified on the Texas coast; but the "norther" lost its force before reaching the Louisiana coast and the warnings were lowered at night on the 19th.

The pressure conditions showed considerable and rapid fluctuations along the middle Gulf coast on the 29th, the fluctuations at New Orleans being most evident in the early part of the night. Small-craft warnings were issued at 9:30 a. m. for the Louisiana coast and the eastern coast of Texas, and northeast storm warnings at 8:30 p. m. on the Louisiana coast east of Morgan City. Moderate easterly gales occurred at New Orleans and fresh to strong easterly gales at Burrwood, La., during the early part of the night. However, the wind diminished greatly by 7 a. m. of the 30th and the warnings were lowered at 9 a. m.

A cold-wave warning was issued for Oklahoma and extreme northwestern Arkansas on the morning of the 4th and was extended in the early afternoon over northeastern Texas, northern Louisiana, and the remainder of Arkansas. The warning was verified in a considerable portion of the area named and the temperature fall was large in all portions.

The temperature fall which overspread the district on the 11th–12th was generally somewhat less than a true cold wave and the warnings issued for much of the northwestern portion of the district on the 10th failed of verification.

During the 18th, 19th, and 20th, a cold wave moved slowly southward over the district to the Texas coast but did not reach the Louisiana coast. Ample warnings were issued well in advance of the cold wave.

A cold-wave warning was issued at night on the 22d for Oklahoma and the Texas Panhandle and was verified. Because of the threatening position of the area of high pressure and a rapid rise in pressure at Oklahoma City, with temperature fall from 30° to 16° between 7 a. m. and 11 a. m., the cold-wave warnings were extended on the 23d over Arkansas, northern Louisiana, and northeastern Texas, but were not generally verified, though sleet occurred with temperatures below freezing.

A cold-wave warning issued on the morning of the 29th for the extreme northwestern portion of the district was justified. Cold-wave warnings were issued for the remainder of the northwestern portion of the district on the morning of the 30th, but the rapid movement of an area of low pressure from the Pacific coast prevented the cold wave from extending farther.

Warnings of frost or freezing temperature were issued on the 1st, 5th, 10th, 11th, 12th, 13th, 16th, 19th, 21st, 24th, 27th, and 28th. Conditions as forecast prevailed in most instances.

Fire-weather warnings were issued for forested areas in Oklahoma and Arkansas on the 2d and conditions occurred as forecast.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

Precipitation in all portions of this district between the 1st and 4th resulted from a storm which moved from the coast of southern California to the middle Mississippi Valley during that period. The disturbance was followed by much colder weather, with temperatures below zero in southwestern Utah. Occasional light snow or rain in southern Arizona, New Mexico, and southeastern Colorado attended a moderate disturbance which advanced from southern California to central Texas from the 7th to the 9th. High pressures prevailed on the middle Plateau from the 7th to the 16th, on which latter date a storm appeared on the north Pacific coast and moved, with increasing intensity, to New Mexico by the 18th, where it remained, slowly filling up, until the 20th, when it advanced to western Texas. Snow fell in Utah and Colorado on the 17th and 18th and in southwestern Colorado and northeastern Arizona on the 19th and 20th, with a cold wave in eastern Colorado on the 18th and in southwestern Utah and most of New Mexico on the 19th. On the last-named date the temperatures were below zero in central and eastern Colorado and western Utah. High

pressures again prevailed over most of the Plateau region from the 19th to the 26th, with fair weather throughout the district after the 20th. During the 27th a storm moved rapidly southward from Alberta to Utah and thence to northwestern Texas by the 29th, where it apparently dissipated, attended during its progress by light precipitation except in the extreme southern portion of the district. The last disturbance of the month appeared on the coast of California on the 29th and advanced rapidly eastward across the States of Utah and Colorado, its center being over southwestern Nebraska on the evening of the 31st. Snow or rain occurred in every part of the district, except portions of New Mexico and along the eastern slope in eastern Colorado, heavy snows falling in southern Utah, northern Arizona, southwestern Colorado, and extreme northwestern New Mexico. This storm was followed during the night of January 31–February 1 by a cold wave in extreme southern Utah and southwestern Colorado.

Warnings of a moderate cold wave were issued for southwestern Colorado, northwestern New Mexico, northeastern Arizona, and extreme southern Utah on the 3d and were fully verified. A cold-wave warning was also issued on the morning of the 18th for southern and western Colorado, New Mexico, northeastern Arizona, and southern Utah. Temperatures below zero were forecast for southern and western Colorado and southern Utah and a fall in temperature of from 20° to 30° for New Mexico by the following morning. The warning was verified except in western Colorado and western New Mexico, where the temperature remained relatively high on account of the slow movement of the LOW. Warnings of a cold wave in western Colorado, northern New Mexico, northeastern Arizona, and southeastern Utah were repeated at 8 p. m. of the 18th, and for southwestern Colorado, west of the mountains in northern New Mexico, and in extreme southeastern Utah at 8 a. m. of the 19th. Owing to the slow movement of the LOW over northwestern New Mexico, already referred to, these warnings were verified in northeastern Arizona and northeastern New Mexico only. Warnings of moderate cold waves in southwestern Utah and eastern Colorado, which were verified, were issued on the morning and evening of the 28th, respectively. Another warning of a moderate cold wave which was issued for eastern Colorado on the evening of the 31st was verified in the extreme eastern portion of the State but failed of verification near the mountains because of the effect of a portion of the LOW which remained over the eastern slope.

Cold waves without warnings occurred at Denver on the 18th, at Durango on the 21st, and at Modena and Flagstaff on the 29th.

Forecast of heavy snow in southern and eastern Colorado, northern New Mexico, northern Arizona, and southern Utah was made on the morning of the 30th and livestock warnings were issued for those sections. The forecast of heavy snow was repeated for the same territory on the evening of the 30th. Heavy snow fell in all of the region indicated except eastern Colorado and north-central and north-eastern New Mexico, seriously interfering with traffic. Press reports from southwestern Colorado indicate that because of the warnings that were distributed there was no loss of stock in that section at least.

Freezing temperature was forecast for south-central and southeastern Arizona on the 4th, 22d, and 23d and for all of the southern portion of that State on the 20th and 21st. Frost or freezing-temperature warnings were issued for Yuma on the 3d, 4th, 7th, 8th, 9th, 14th, 15th, 16th, from the 18th to the 28th, inclusive, and on the 31st. These forecasts were generally varified, either by the occurrence of freezing temperature or frost, or temperatures at which frost might be expected.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT.

Precipitation in the San Francisco Forecast District during January occurred in three periods. The first early in the month; the 2d—a short one—near the middle of the month, and the 3d at the close of the month. All three were due to extensions of low-pressure areas from Bering Sea that moved south near the coast. Except at the time of these rainy periods, the weather was controlled by high-pressure areas over the central Plateau States. They from time to time accumulated off-shoots from the permanent Pacific HIGH and in one case from a large HIGH that moved south from the Yukon country. The central Plateau HIGH also sent out offshoots that moved eastward to the Atlantic States.

At the time and for several days after the merging of the Yukon HIGH with the central Plateau HIGH, the coldest weather for many years prevailed in California and Nevada. This HIGH at about this time became so pronounced that it included the entire United States within its boundary.

The lowest barometer readings at the Bering Sea stations were 28.62 inches at Kodiak on January 3, and 28.40 inches at Dutch Harbor on January 5. Neither of these storms was followed by especially severe weather in this district.

On the 23d–24th a rather remarkable change in pressure occurred about 750 miles off the California coast. The barometer reading on the 23d was 29.70 inches, reported by one vessel and confirmed by another. The next day this low area was replaced by a HIGH with a barometer reading of 30.30 inches. Where this distrubance went is not known, but it probably moved southeastward and later crossed Mexico, and appeared in the Gulf of that name. This disturbance was a menace to this district; but fortunately no mistake was made, as it was too far away to affect the forecast on the day it was first noted and it disappeared the next day.

Storm warnings were ordered on 10 days for one or more portions of the district and small-craft warnings were ordered on three occasions. These warnings were timely and justified in whole or in part.

Frost warnings were issued on 24 occasions and in nearly every instance were fully verified. On the 20th, 21st, and 22d killing frosts did great harm to the citrus fruit and winter garden truck in southern and central California. The frosts on the other days were not especially damaging, as the staple crops were mostly dormant and therefore not susceptible to injury by frost.

Two cold-wave warnings were issued, and both were verified.—*E. A. Beals.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

The crest of the Ohio River flood of the last week of December, 1921, reached the Mississippi River on January 3, with a crest stage at Cairo, Ill., of 39 feet, 6 feet below flood stage. As the Cumberland and Tennessee Rivers were not high, there were no flood stages in the Ohio below the mouth of the Wabash River. From Dam No. 48 (Cypress, Ind.), to Shawneetown, Ill., the crest stages were from 7 to 9 feet above the flood stages. The aggregate of loss and damage was small, not over $15,000, mainly in crops, while the reported value of

property saved by the flood warnings amounted to $200,550.

The floods in the lower White and lower Wabash Rivers were moderate, except that of the extreme lower Wabash, Mount Carmel, Ill., experiencing a crest stage of 20.5 feet, or 5.5 feet above flood stage, on January 1. Several hundred acres of wheat and clover were flooded, but it is thought that under favorable weather conditions they will survive. The value of property saved through the warnings was about $10,000.

There were two moderate floods in the Santee River of South Carolina, one about the middle of the month, and the other from the 24th to the 30th, inclusive. Crest stages were from 1 to 1½ feet above the flood stage of 12 feet. Warnings were issued at the proper time and no damage occurred.

There was also a moderate flood without damage in the Apalachicola River of Florida from the accumulated waters of the Flint and Chattahoochee Rivers. Warnings were issued on January 14, and the crests occurred on January 15. There was no damage. Moderate to heavy rains over the drainage basin of the lower Coosa River on January 19 and 20, resulted in river stages from 4 to 7 feet above the flood stages as far down as Lincoln, Ala. Warnings were issued promptly, and losses and damage were negligible, as there was ample time to remove portable property.

The same general conditions also caused a general and more decided flood in the Black Warrior and lower Tombigbee Rivers of Alabama, and the Tombigbee did not fall below the flood stage at Demopolis, Ala., until after the close of the month. At Tuscaloosa, Ala., on the Black Warrior River, the crest stage on January 22, was 55.2 feet, 9.1 feet above flood stage, the high water continuing for four days, while at Demopolis the crest stage of 46.1 feet, 7.1 feet above flood stage, was reached on January 29, the river remaining above the flood stage for eight days. Some lowlands were inundated but there were no losses of consequence, and the high stages were of benefit to lumbermen interested in floating out timber.

The rains of January 20 and 21, were heavy and very general over the entire South, and floods set in over the headwaters of the Tennessee River, about the same time as in the rivers to the southward. The flood waters gradually extended along the Tennessee River, reaching the mouth of the river about the end of the month, although actual flood stages were not reached much below Riverton, Ala. Crest stages were a few feet above flood stages as a rule, and warnings appear to have been issued in ample time to all interested. No losses were reported except a very small amount in the vicinity of Riverton, Ala.

The Illinois River flood continued throughout the month without incident. Stages were too low to cause damage.

The only other floods reported were flash rises in the vicinity of Phoenix, Ariz., on January 2 and 3, one in Salt River, and one in Cave Creek, the latter ordinarily a dry channel. Warnings were issued by telephone, and irrigation projects were able to protect dams and guard canals. No damage was reported along Salt River, but the Cave Creek flood caused an 80-foot break in the south bank of the Arizona Irrigation Canal and the overflow waters overspread a large area of farm land and a portion of the northwestern section of the city of Phoenix. As crops were all gathered, the flood caused inconvenience rather than loss, and the damage to irrigation canals approximated only $1,500.

Flood stages during January, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
Santee:	*Feet.*			*Feet.*	
Rimini, S. C.	12	12	16	13.2	15
	12	26	29	13.4	27
Ferguson, S. C.	12	14	20	12.7	17
	12	24	30	12.6	25, 28
Apalachicola:					
River Junction, Fla	12	13	14	12.4	14
Blountstown, Fla	15	14	14	15.1	24
Coosa:					
Gadsden, Ala.	22	22	29	24.8	23
Lock No. 4 (Lincoln, Ala.)	17	22	30	20.5	22–23
Etowah:					
Canton, Ga	11	22	23	15.2	22
Oostanaula:					
Resaca, Ga	25	21	25	32.0	22
Tombigbee:					
Demopolis, Ala	39	25	(**)	46.1	29
Black Warrior:					
Tuscaloosa, Ala	46	22	24	55.2	22
MISSISSIPPI DRAINAGE.					
Ohio:					
Cloverport, Ky	40	(*)	2	43.4	1
Dam No. 48, Ind	35	(*)	5	42.0	1
Henderson, Ky	33	(*)	5	40.9	1
Evansville, Ind	35	(*)	5	42.6	1
Mount Vernon, Ind	35	(*)	6	42.6	1
Shawneetown, Ill	35	(*)	7	44.3	2
Green:					
Lock No. 2 (Rumsey, Ky.)	34	(*)	1	34.1	1
Wabash:					
Mount Carmel, Ill	15	(*)	5	20.5	1
White:					
Decker, Ind	18	(*)	4	22.9	1
East Fork of White:					
Shoals, Ind	20	(*)	1	23.7	1
Tennessee:					
Knoxville, Tenn	12	21	23	19.0	22
Chattanooga, Tenn	33	23	25	35.8	24
Bridgeport, Ala	24	24	25	24.2	25
Guntersville, Ala	31	24	27	33.1	26
Florence, Ala	18	24	29	19.1	28
Riverton, Ala	32	23	30	37.9	28
North Fork of Holston:					
Mendota, Va	8	20	20	9.7	20
	8	22	22	9.0	22
French Broad:					
Dandridge, Tenn	12	22	22	12.6	22
Big Pigeon:					
Newport, Tenn	6	20	22	10.2	21
Little Tennessee:					
McGhee, Tenn	20	22	22	23.7	22
Hiwasee:					
Charleston, Tenn	22	21	23	26.7	22
Illinois:					
Peru, Ill	14	(*)	20	17.2	7
Henry, Ill	7	(*)	23	9.2	9–10
Peoria, Ill	16	7	13	16.3	12
Beardstown, Ill	12	(*)	20	14.0	7–10
COLORADO DRAINAGE.					
Salt:					
Phoenix, Ariz	5	3	3	7.2	3

* Continued from December, 1921.
** Continued into February, 1922.

MEAN LAKE LEVELS DURING JANUARY, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Feb. 6, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during January, 1922:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.62	579.32	571.51	244.73
Above or below—				
Mean stage of December, 1921	−0.37	−0.22	−0.20	−0.10
Mean stage of January, 1921	−0.46	−0.60	−0.48	−0.81
Average stage for January, last 10 years	−0.52	−0.70	−0.21	−0.76
Highest recorded, January stage	−1.16	−3.35	−2.04	−2.87
Lowest recorded January stage	+0.74	+0.24	+0.55	+0.93
Average relation of the January level to:				
December level	....	−0.20	−0.10	0.00
February level	....	0.00	+0.10	0.00

* Lake St. Clair's level: In January, 573.93 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, JANUARY, 1922.

J. WARREN SMITH, Meteorologist.

The month of January, 1922, was persistently cold west of the Rocky Mountains, while temperatures varied greatly from week to week in the Central and Eastern States. The month was mostly favorable for the usual mid-winter outdoor operations, except for the cold weather in the West, and during the last 10 days in the Northwest.

Much less than the usual amount of snow fell in the principal winter-wheat States, the ground being bare during most of the month, but extremely heavy snowfall was experienced in the Middle Atlantic States, and moderately heavy falls in the Northeast. Grain fields were mostly well protected by snow-cover in the far Northwestern States during the periods of severely cold weather. In the absence of snow protection, winter grains were somewhat adversely affected by alternate thawing and freezing in the Ohio Valley States, but no extensive harm was reported. Very little precipitation occurred from Kansas and eastern Colorado southward and severe drought prevailed in that area which was very unfavorable for winter grains.

Comparatively mild weather favored the development of winter truck in the South, although there was some local frost injury in the more southeastern districts during the latter part of the month, and much damage was done in California to many winter crops. Much of the potato crop was planted in Florida the last half of the month under generally favorable weather conditions. Field work was interrupted by frequent rains in some Southern States, especially during the latter part of the month.

The unusually cold weather from the Rocky Mountains westward was unfavorable for stock, and heavy feeding was necessary in many localities, with considerable loss and shrinkage. Stock water continued scarce in dry southwestern districts, although the general precipitation from southern Arizona westward during the last week of the month was beneficial, and there was sufficient moisture to improve ranges in much of Texas and New Mexico.

The month was generally favorable for fruit, except for the severe freeze in California. The worst freeze in many years occurred in that State about the 20th and great damage was done to citrus fruits, especially where orchards were unprotected. Orchardists were given timely warning of the approaching freeze and a vast quantity of fruit was saved by heating. The colder weather the latter part of the month was favorable in Southeastern States in retarding premature development of deciduous fruit bloom. Berries were plentiful in Florida at the close of the month.

CLIMATOLOGICAL TABLES.*

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau, the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, January, 1922.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	47.4	+1.1	5 stations	79	19†	Maple Grove	15	2	7.08	+2.30	Valley Head	10.41	Alaga	3.10
Alaska														
Arizona	39.5	−2.9	Camelback	80	2	Chin Lee	−23	22	1.91	+0.45	Ashdale R. S	7.60	Benson	T.
Arkansas	39.1	−1.8	Huttig	74	4	2 stations	10	19	2.63	−1.60	El Dorado	7.98	Morrillton	0.77
California	41.8	−4.0	Santa Ana	82	14	Madeline	−28	19	3.47	−1.94	Squirrel Inn	14.48	Bagdad	0.22
Colorado	20.1	−3.0	2 stations	73	2†	Fraser	−45	20	0.85	−0.01	Cumbres	8.07	4 stations	0.00
Florida	59.0	−0.3	Inverness	92	21	De Funiak Springs	21	14	2.19	−0.89	Bluff Springs	5.92	Homestead	0.25
Georgia	46.6	−0.2	3 stations	82	21	Blue Ridge	12	2†	4.71	+0.77	Blue Ridge	11.65	St. George	2.25
Hawaii														
Idaho	15.3	−7.6	Lewiston	51	9	Felt	−50	19	1.48	−0.90	Musselshell	4.11	Pleasant Valley	0.38
Illinois	25.9	−0.6	Sparta	69	4	Kankakee	−11	25	1.28	−1.16	White Hall	2.30	Edwardsville	0.60
Indiana	26.7	−1.9	Shelbyville	67	4	Goshen	−25	25	1.65	−1.54	Salem	2.89	Connersville	0.76
Iowa	19.8	+1.9	Harlan	57	1	2 stations	−29	24	0.89	−0.16	Rockwell City	2.30	Postville	0.32
Kansas	28.5	−1.2	Atwood	72	2	St. Francis	− 7	30	0.41	−0.30	Hanover	1.60	Phillipsburg	0.00
Kentucky	34.6	−0.6	Saint John	67	4	Middlesboro	1	14	2.25	−2.14	Junction City	5.48	Henderson	0.71
Louisiana	51.0	−0.1	Jeanerette	84	4	Bastrop	21	2	5.96	+1.70	Ludington	10.80	Burrwood	3.04
Maryland-Delaware	30.3	−2.3	Great Falls, Md	63	5	Oakland, Md	−15	17	3.96	+0.71	Cheltenham, Md	5.63	Clear Spring, Md	1.39
Michigan	19.0	−1.1	Monroe	54	5	Humboldt	−41	25	1.31	−0.73	Calumet	3.20	Hastings	0.37
Minnesota	9.4	+1.9	Milan	49	2	2 stations	−51	22†	0.65	−0.12	St. Cloud	1.88	Fosston	0.05
Mississippi	46.7	−0.2	Woodville	81	19	2 stations	20	2	6.52	+1.49	Shubuta	11.03	Hernando	2.15
Missouri	29.5	−0.6	Jefferson City (2)	66	3†	Mexico	− 6	23	1.21	−1.05	Nevada	6.15	Lexington	0.32
Montana	15.1	−3.5	Winifred	60	8	Medicine Lake	−42	22	0.70	−0.35	Heron	4.32	2 stations	0.06
Nebraska														
Nevada	22.2	−9.2	Las Vegas	66	10	San Jacinto	−39	19	1.13	+0.02	Mahoney Ranger Sta	3.44	Quinn River Ranch	0.13
New England	18.4	−2.1	Rutland, Vt	58	5	Van Buren, Me	−38	24	2.04	−1.35	Kingston, R. I	3.88	Cornwall, Vt	0.79
New Jersey	27.6	−2.3	Asbury Park	57	5	Culvers Lake	−13	26	2.62	−0.99	Tuckerton	4.13	Boonton	1.08
New Mexico	31.3	−2.9	Pearl (near)	73	17	2 stations	−19	21	0.51	−0.16	Mountain Park	2.71	3 stations	0.00
New York	19.6	−3.3	Sharon Springs (1)	55	5	Wanakena	−37	25	2.21	−0.75	Dannemora	4.95	Chazy	0.83
North Carolina	39.8	−1.3	2 stations	82	21	Parker	− 1	14	4.58	+0.87	Rock House	9.22	Banners Elk	2.13
North Dakota	7.0	+2.1	Medora	55	6	Minot	−46	23	0.49	−0.05	Amenia	1.60	3 stations	0.10
Ohio	26.4	−2.2	Waverly	69	5	Paulding	−20	25	1.62	−1.49	Green	3.41	Milfordton	0.70
Oklahoma	36.1	−2.6	Poteau	77	4	Blackwell	− 7	21	1.50	+0.26	Meeker	2.58	Kenton	0.06
Oregon	27.4	−6.0	Port Orford	67	11	Drewsey	−39	20	2.77	−1.85	Government Camp	10.59	Tule Lake	0.16
Pennsylvania	25.0	−3.1	3 stations	62	5	3 stations	−19	24†	2.26	−0.93	Coatesville	4.46	Lawrenceville	1.15
Porto Rico														
South Carolina	44.2	−1.3	3 stations	81	20†	Santuck	14	2	3.53	+0.07	Landrum	8.64	Florence No. 1	1.57
South Dakota	13.8	−0.4	Alexandria	60	14	Pine Ridge	−30	30	0.95	+0.47	Sioux Falls	2.23	Eureka	0.16
Tennessee	38.9	−0.2	2 stations	69	4	Crossville	− 3	14	4.36	−0.70	Copperhill	8.67	Memphis	2.26
Texas	45.9	−2.5	Falfurrias	92	18	Romero	− 5	19	2.47	+0.72	Beaumont	9.34	2 stations	T.
Utah	18.1	−6.9	Springdale	64	1	East Portal	−42	19	1.29	−0.15	Silver Lake	4.91	Lemay	0.05
Virginia	33.9	−2.4	Runnymede	72	5	2 stations	− 5	13†	4.00	+0.63	Guinea Mills	6.20	Winchester	1.83
Washington	24.9	−5.9	North Head	60	11	Lowden	−28	18	2.10	−2.44	Paradise Inn	12.65	Wapato	0.07
West Virginia	30.2	−1.9	Glenville	68	4	Cheat Bridge	−15	13	2.75	−1.16	Bayard	4.81	Camden-On-Gauley	1.01
Wisconsin	13.2	−0.6	Prairie du Sac	51	31	Danbury	−54	24	0.80	−0.48	Stevens Point	1.87	Coddington	0.10
Wyoming	12.3	−7.1	Chugwater	59	16	Moran	−51	19	0.79	−0.07	Moran	2.04	Hyattville	0.00

* For description of tables and charts, see REVIEW, for January, 1921, p. 41

† Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, January, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England.							22.7	− 1.4										71	2.11	− 1.4										4.7		
Eastport	76	67	85	29.98	30.07	+ .07	19.6	− 0.5	45	12	28	−11	24	12	33	18	12	71	1.90	− 1.9	9	10,428	nw.	74	ne	11	13	6	12	5.1	14.0	1.8
Greenville, Me	1,070	6	....	28.86	30.10	......	11.0	......	32	6	21	−29	23	1	32	......	......	......	2.02	......	9	......	......	......	......	......	20	5	6		20.3	15.0
Portland, Me	103	82	117	30.01	30.14	+ .09	20.8	− 1.2	41	15	28	− 7	24	14	30	17	9	63	3.40	− 0.4	8	6,787	nw.	40	ne.	11	20	4	7	3.5	13.8	13.0
Concord	288	70	79	29.81	30.14	+ .09	17.8	− 3.4	43	15	28	−23	24	8	37	......	......	......	1.73	− 1.6	6	3,924	nw.	38	w.	22	18	5	8	4.0	13.2	9.1
Burlington	404	11	48	29.70	30.18	+ .13	15.0	− 1.3	45	5	24	−15	26	6	32	......	......	......	1.26	− 0.6	7	9,918	s.	56	s.	15	11	7	13	5.0	13.8	5.0
Northfield	876	12	60	29.17	30.18	+ .13	12.2	− 2.9	49	5	25	−28	26	0	43	8	5	84	1.21	− 1.3	10	5,530	s.	34	sw.	22	11	11	9	4.0	15.7	11.1
Boston	125	115	188	29.99	30.13	+ .08	27.2	+ 0.2	51	5	34	0	25	20	24	23	15	60	1.41	− 2.4	4	8,715	w.	52	ne.	11	12	10	9	4.6	2.7	0.2
Nantucket	12	14	90	30.10	30.11	+ .07	30.0	− 2.1	49	5	36	8	25	24	21	27	23	77	3.68	+ 0.3	10	13,292	nw.	67	ne.	29	8	11	12	6.3	0.5	0.0
Block Island	26	11	46	30.10	30.13	+ .06	29.6	− 1.8	50	5	36	4	25	24	22	27	22	73	3.04	− 0.8	11	16,960	nw.	70	ne.	11	12	9	10	4.9	3.1	T.
Providence	160	215	251	29.96	30.14	+ .08	26.6	− 0.6	50	5	34	1	25	19	21	23	15	64	1.36	− 3.0	8	10,855	nw.	60	nw.	22	14	11	6	4.1	2.7	T
Hartford	159	122	140	......	30.17	+ .10	24.8	− 0.7	49	5	33	− 2	26	17	27	......	......	......	2.19	− 1.6	8	6,018	nw.	32	nw.	22	13	8	10	....	6.6	2.5
New Haven	106	74	153	30.04	30.17	+ .09	26.6	− 0.7	49	5	34	3	25	20	22	23	18	73	2.08	− 1.8	11	6,605	ne.	34	ne.	28	13	8	10	4.9	7.4	1.2
Middle Atlantic States.							30.3	− 1.2										71	3.24	0.0										1.9		
Albany	97	102	115	30.03	30.20	+ .13	20.6	− 1.9	46	5	29	−10	26	12	28	18	14	80	2.00	− 0.6	8	6,179	nw.	34	s.	8	16	7	8	4.4	16.7	4.0
Binghamton	871	10	84	29.20	30.17	+ .09	21.2	− 1.9	54	5	31	−13	26	12	35	......	......	......	1.85	− 0.1	9	4,625	nw.	30	w.	22	10	10	11	5.8	15.9	3.0
New York	314	414	454	29.81	30.17	+ .07	29.0	− 1.2	50	5	36	6	26	22	26	25	17	61	2.46	− 1.3	8	13,470	nw.	67	nw.	2	10	10	11	5.6	9.9	3.3
Harrisburg	374	94	104	29.79	30.22	+ .12	26.9	− 1.8	52	5	34	4	26	20	25	23	16	66	2.49	− 0.3	10	5,391	nw.	35	ne.	11	11	8	12	5.2	16.8	4.5
Philadelphia	117	123	190	30.06	30.20	+ .09	31.2	− 0.6	53	5	37	9	26	25	22	27	21	66	3.16	− 0.2	8	7,801	n.	46	n.	28	9	9	13	5.8	15.6	6.6
Reading	325	81	98	29.84	30.21	......	27.8	......	51	5	35	6	26	21	24	25	21	78	2.16	− 1.4	8	5,419	nw.	31	n.	11	12	7	12	5.6	18.8	6.0
Scranton	805	111	119	29.29	30.19	+ .10	24.1	− 1.4	51	5	32	− 2	26	16	28	21	16	76	1.96	− 0.8	7	5,865	sw.	40	nw.	11	10	12	9	5.4	10.2	0.7
Atlantic City	52	37	48	30.12	30.18	+ .07	32.2	− 0.3	53	5	39	11	25	26	22	28	24	75	4.04	+ 0.6	10	14,370	nw.	74	e.	11	11	4	16	5.6	9.2	5.0
Cape May	18	13	49	30.19	30.21	+ .09	32.4	− 1.7	53	5	39	11	26	26	22	28	24	76	3.95	+ 0.6	12	8,010	n.	48	nw.	2	13	4	14	5.5	9.1	1.8
Sandy Hook	22	10	55	30.14	30.17	......	29.3	......	50	5	35	10	2	24	20	26	20	68	1.74	......	8	14,099	nw.	72	ne.	11	12	8	11	5.1	3.7	1.0
Trenton	190	159	183	29.96	30.18	......	28.4	......	52	5	36	5	26	21	23	25	20	72	2.41	− 0.8	7	9,733	w.	60	ne.	11	7	9	15	6.1	13.5	7.5
Baltimore	123	100	113	30.08	30.23	+ .08	32.2	− 1.2	61	5	38	13	25	26	23	28	21	64	4.88	+ 1.7	11	4,820	n.	41	ne.	11	10	4	17	6.1	31.3	14.8
Washington	112	62	85	30.08	30.20	+ .07	32.0	− 0.9	62	5	39	11	26	25	31	28	20	66	5.56	+ 2.2	9	5,705	n.	38	nw.	11	7	7	17	6.7	31.5	17.0
Lynchburg	681	153	188	29.42	30.19	+ .06	35.1	− 0.7	62	5	44	8	25	27	38	31	26	71	3.90	+ 0.2	12	6,350	nw.	30	nw.	12	8	9	14	6.0	22.7	7.6
Norfolk	91	170	205	30.08	30.19	+ .06	39.2	− 0.2	69	21	46	20	25	32	31	34	28	71	3.49	+ 0.1	12	12,187	ne.	52	sw.	11	5	7	19	7.3	3.4	0.0
Richmond	144	11	52	30.04	30.21	+ .08	35.0	− 3.0	65	5	42	13	25	28	31	30	24	69	4.58	+ 1.6	10	7,247	ne.	36	sw.	5	8	4	19	6.9	22.1	5.0
Wytheville	2,304	49	56	27.73	30.21	+ .07	32.6	− 0.4	59	4	40	10	26	25	28	29	25	79	2.90	− 1.3	10	4,844	w.	30	sw.	3	7	4	20	7.2	13.8	0.5
South Atlantic States.							44.6	− 0.5										79	3.69	− 0.1										6.6		
Asheville	2,255	70	84	27.76	30.20	+ .05	38.2	+ 2.8	63	4	40	12	14	31	30	34	29	76	2.84	− 1.8	12	6,925	nw.	34	e.	11	6	6	19	7.1	4.7	0.0
Charlotte	779	55	62	29.33	30.19	+ .04	40.2	− 0.2	68	21	48	18	26	33	23	36	31	74	5.24	+ 1.0	13	5,292	ne.	24	nw.	11	6	7	18	7.2	1.8	0.0
Hatteras	11	12	50	30.13	30.14	.00	45.8	0.0	69	2	52	25	2	39	23	42	40	85	7.58	+ 2.6	10	15,362	n.	52	nw.	29	7	7	17	6.9	T	0.0
Manteo	12	5	42	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Raleigh	376	103	110	29.78	30.20	+ .07	38.6	− 1.8	72	21	46	18	25	31	30	35	32	80	4.09	+ 0.5	11	7,417	ne.	33	w.	11	6	3	22	7.4	8.9	3.2
Wilmington	78	8	91	30.10	30.19	+ .05	44.0	− 1.6	76	21	52	22	25	36	25	40	36	79	3.57	+ 0.1	9	6,961	n.	30	s.	11	9	6	16	6.4	2.4	0.0
Charleston	48	11	92	30.13	30.18	+ .05	47.4	− 1.9	74	6	55	26	26	40	24	42	39	80	2.48	− 1.0	9	8,942	n.	37	s.	11	11	7	13	5.9	0.0	0.0
Columbia, S. C.	351	41	57	29.82	30.21	+ .06	44.1	− 1.0	78	21	52	24	26	35	29	39	35	77	2.22	− 1.1	9	5,980	ne.	28	sw.	21	9	7	15	6.8	0.7	0.0
Due West	711	10	55	29.42	30.22	......	42.2	......	68	21	49	19	2	35	29	......	......	......	3.92	......	11	7,358	ne.	34	nw.	11	7	7	17	7.0	0.4	0.0
Greenville, S. C.	1,039	113	122	29.05	30.18	......	41.8	......	66	21	48	21	26	35	27	37	33	78	5.32	......	15	7,153	ne.	32	sw.	13	6	9	16	6.7	3.1	0.0
Augusta	180	62	77	30.00	30.20	+ .04	45.8	− 0.1	78	21	54	23	2	38	33	41	38	79	2.70	− 1.4	10	4,951	ne.	25	nw.	11	8	9	14	6.5	0.8	0.0
Savannah	65	150	194	30.11	30.19	+ .04	49.0	− 0.9	78	6	56	27	26	42	27	43	39	78	3.01	− 0.1	7	9,227	ne.	50	w.	11	11	7	13	6.0	0.0	0.0
Jacksonville	43	209	245	30.13	30.18	+ .03	53.4	− 0.5	78	21	60	30	2	46	24	49	46	85	3.21	+ 0.1	9	9,215	n.	48	sw.	11	12	6	13	5.9	0.0	0.0
Florida Peninsula.							66.5	+ 1.1										78	1.44	− 1.3										4.6		
Key West	22	10	64	30.07	30.09	− .01	70.4	+ 1.6	80	10	75	55	14	66	13	65	62	81	2.60	+ 0.6	10	8,249	e.	37	w.	11	14	12	5	4.2	0.0	0.0
Miami	25	71	79	30.10	30.13	......	67.6	+ 0.3	80	9	74	40	13	61	28	62	58	77	0.55	− 2.9	7	6,190	e.	30	sw.	11	9	14	8	4.6	0.0	0.0
Sand Key	23	39	72	30.08	30.11	+ .01	70.2	......	77	27	73	56	13	68	13	66	63	77	3.04	......	9	12,715	e.	48	nw.	12	13	14	4	4.0	0.0	0.0
Tampa	35	79	92	30.11	30.15	+ .03	61.4	+ 1.3	83	23	70	37	2	53	27	55	51	78	1.16	− 1.6	6	5,207	ne.	30	se.	30	6	17	8	5.8	0.0	0.0
East Gulf States.							49.0	+ 1.6										80	5.59	+ 0.6										7.1		
Atlanta	1,174	190	216	28.92	30.19	+ .04	43.0	+ 0.8	68	19	50	21	2	36	24	40	36	81	5.03	− 0.3	15	9,552	nw.	44	nw.	1	9	2	20	6.9	1.0	0.0
Macon	370	78	87	29.79	30.20	+ .04	46.6	+ 1.0	76	21	55	25	2	38	30	41	37	75	3.16	− 2.0	12	5,730	ne.	29	nw.	1	8	6	17	6.8	0.0	0.0
Thomasville	273	49	58	29.87	30.18	+ .02	51.6	+ 0.6	76	6	60	28	2	44	32	46	42	77	2.72	− 1.4	9	3,786	ne.	24	sw.	10	7	5	19	7.2	0.0	0.0
Pensacola	56	149	185	30.10	30.16	+ .02	54.2	+ 1.9	71	19	60	33	2	49	23	51	49	86	4.62	+ 0.6	10	11,526	ne.	55	se.	29	7	4	20	7.0	0.0	0.0
Anniston	741	9	57	29.39	30.20	+ .04	45.2	+ 3.0	72	19	53	18	2	37	32	......	......	......	5.83	+ 0.5	15	5,319	se.	26	se.	10	6	10	15	6.8	T.	0.0
Birmingham	700	11	48	29.42	30.20	+ .04	45.9	+ 0.6	74	19	54	23	2	38	30	41	36	74	6.20	+ 0.9	12	6,084	n.	29	s.	4	4	10	17	7.4	0.0	0.0
Mobile	57	125	161	30.09	30.15	.00	53.0	+ 3.2	72	21	60	32	2	46	24	49	47	84	6.79	+ 1.9	13	8,515	ne.	37	n.	1	5	8	18	7.0	0.0	0.0
Montgomery	223	100	112	29.94	30.20	+ .04	48.7	+ 1.0	77	19	56	27	2	42	27	44	40	77	6.94	+ 1.8	13	5,982	ne.	23	w.	10	5	10	16	7.1	T.	0.0
Corinth	460	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Meridian	375	85	93	29.76	30.17	+ .01	47.7	+ 2.7	78	19	55	26	2	40	33	43	40	79	8.49	+ 3.0	16	5,277	ne.	25	sw.	10	4	7	20	7.4	0.0	0.0
Vicksburg	247	65	73	29.90	30.19	+ .04	46.9	− 0.1	75	4	54	30	2	40	33	43	41	86	6.46	+ 0.8	16	5,970	ne.	26	sw.	4	4	7	20	7.4	0.0	0.0
New Orleans	53	76	84	30.08	30.14	+ .01	56.0	+ 3.0	80	19	63	37	2	49	25	52	49	84	5.22	+ 0.6	15	6,300	ne.	42	ne.	29	7	6	18	7.1	0.0	0.0
West Gulf States.							45.2	− 0.9										78	3.15	+ 0.1										7.2		
Shreveport	249	77	93	29.90	30.18	+ .04	44.6	− 1.6	73	18	52	29	12	38	33	41	38	82	5.73	+ 1.3	17	5,943	ne.	27	w.	10	5	3	23	7.8	0.6	0.0
Bentonville	1,303	11	44	......	......	......	34.8	+ 0.7	64	4	44	10	19	26	41	......	......	......	1.37	......	6	......	......	......	......	......	8	4	19	......	1.1	0.0
Fort Smith	457	79	94	29.68	30.18	+ .04	39.0	+ 0.7	69	4	47	18	19	31	39	35	30	74	2.44	− 0.1	8	6,438	e.	54	sw.	4	7	4	20	6.9	1.3	0.0
Little Rock	357	136	144	29.80	30.18	+ .03	39.8	− 0.8	67	4	47	24	25	33	33	36	31	73	1.90	− 2.9	9	6,309	n.	41	nw.	11	7	4	20	7.2	T.	0.0
Brownsville	57	4	25	......	......	......	57.8	......	84	19	66	34	20	49	38	......	......	......	1.51	......	14	......	n.	......	......	......	......	......	......	......	0.0	0.0
Corpus Christi	20	69	77	30.10	30.12	+ .02	53.5	0.0	77	18	61	30	20	46	39	49	46	81	1.12	− 1.1	10	9,566	n.	38	n.	10	6	4	21	7.4	0.0	0.0
Dallas	512	109	117	29.62	30.19	......	43.2	......	74	18	51	22	19	35	39	......	......	......	2.00	......	9	6,049	nw.	39	s.	3	7	6	18	7.2	T.	0.0
Fort Worth	670	106	114	29.92	30.15	+ .03	43.0	− 1.3	73	18	52	19	19	34	41	38	32	71	1.63	+ 0.7	12	6,806	e.	34	nw.	10	7	6	18	6.9	T	0.0
Galveston	54	106	114	30.08	30.14	+ .03	52.0	− 0.7	72	4	57	35	12	47	28	49	47	87	4.84	+ 1.2	18	9,911	n.	42	w.	10	6	2	23	7.7	0.0	0.0
Groesbeck	461	11	56	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Houston	138	111	121	29.97	30.12	......	50.5	− 2.4	78	3	57	30	20	44	39	......	......	......	5.98	......	17	6,818	n.	35	nw.	10	7	4	20	7.4	0.0	0.0
Palestine	510	64	72	29.62	30.16	+ .04	45.0	− 1.5	76	3	52	24	20	38	35	41	36	76	5.62	+ 1.8	15	6,722	ne.	30	s.	15	4	3	24	8.0	T.	0.0
Port Arthur	34	58	66	30.08	30.12	......	50.4	......	75	4	56	31	12	45	31	48	46	89	5.06	......	21	8,341	ne.	37	nw.	10	5	5	21	7.6	0.0	0.0
San Antonio	701	119	132	29.38	30.13	+ .03	49.4	− 1.7	79	18	57	29	20	42	33	43	37	68	1.23	− 0.4	11	6,285	ne.	45	nw.	10	3	7	21	7.1	0.0	0.0
Taylor	582	55	63	29.54	30.18	+ .07	45.7	− 1.8	75	3	53	25	20	38	35	......	......	......	3.62	+ 0.8	12	7,048	n.	31	s.	3	4	4	23	8.1	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, January, 1922*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with .01, or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee.							**32.8**	**− 0.3**										**74**	**2.44**	**− 1.4**										**6.1**		
Chattanooga	762	189	213	29.38	30.21	+ .05	41.5	+ 0.9	64	19	48	20	2	35	26	37	32	72	6.29	+ 0.7	19	5,831	n.	36	nw.	11	4	7	20	7.4	4.1	0.0
Knoxville	996	102	111	29.11	30.19	+ .04	39.7	+ 2.2	64	4	47	18	2	33	28	36	32	78	4.64	− 0.3	16	4,563	ne.	28	sw.	4	2	10	19	7.6	1.8	0.0
Memphis	399	76	97	29.79	30.23	+ .07	40.0	− 0.3	69	4	47	22	24	33	33	36	32	76	2.26	− 3.0	9	6,372	n.	34	w.	4	5	6	20	7.6	T.	0.0
Nashville	546	168	191	29.62	30.22	+ .06	38.9	+ 0.9	64	4	47	19	2	31	31	35	30	74	2.90	− 2.0	14	7,670	ne.	37	nw.	11	7	7	17	6.5	0.9	0.0
Lexington	989	193	230	29.11	30.22	+ .09	32.6	− 0.4	59	4	40	10	25	25	30	.....	.....	.....	1.87	− 2.0	11	10,886	ne.	42	sw.	15	11	6	14	5.9	2.2	0.0
Louisville	525	219	255	29.64	30.24	+ .10	33.4	− 0.9	63	4	41	12	24	26	31	30	25	71	1.59	− 2.3	9	9,433	ne.	50	w.	4	13	7	11	5.1	1.5	0.0
Evansville	431	130	175	29.74	30.23	+ .09	32.3	0.0	62	4	40	11	25	25	27	29	24	71	1.47	− 2.2	10	9,170	ne.	40	n.	11	7	14	10	6.1	0.4	0.0
Indianapolis	822	194	230	29.29	30.21	+ .09	26.7	− 1.5	60	4	35	− 1	25	18	35	24	18	72	1.26	− 1.6	9	9,335	ne.	38	sw.	14	12	7	12	5.4	2.9	0.0
Royal Center	736	11	55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Terra Haute	575	96	129	29.55	30.20	+ .06	27.4	.....	60	4	36	1	23	19	35	24	19	73	1.14	.....	7	7,327	ne.	35	sw.	14	7	14	10	5.7	4.0	0.0
Cincinnati	628	11	51	29.52	30.22	+ .10	29.2	− 1.1	61	4	38	6	25	21	31	.....	.....	.....	2.07	− 1.3	10	6,537	ne.	30	nw.	11	12	8	11	5.4	1.8	0.0
Columbus	824	179	222	29.29	30.20	+ .09	27.2	− 1.4	59	4	36	3	23	19	30	24	19	73	1.80	− 1.2	10	8,763	sw.	38	nw.	11	11	7	13	5.3	3.4	0.0
Dayton	899	181	216	29.19	30.19	.....	27.8	− 1.1	56	4	36	4	25	20	28	24	19	74	1.43	− 1.6	7	8,545	ne.	44	ne.	11	12	8	11	5.1	3.7	0.0
Elkins	1,947	59	67	28.07	30.23	+ .11	29.3	+ 0.3	63	4	40	0	13	19	39	25	21	80	3.18	− 0.2	14	4,414	w.	31	nw.	11	7	7	17	6.9	15.4	0.0
Parkersburg	638	77	84	29.59	30.23	+ .11	31.8	+ 0.5	64	4	40	8	25	24	33	28	22	71	1.91	− 1.3	13	4,639	w.	29	nw.	1	13	6	12	5.5	1.3	0.0
Pittsburgh	842	353	410	29.27	30.21	+ .10	28.8	− 1.9	59	4	37	6	24	21	26	25	20	71	1.56	− 1.3	10	8,721	sw.	39	nw.	11	10	6	15	5.8	6.3	0.0
Lower Lake Region.							**22.5**	**− 1.9**										**73**	**1.85**	**− 0.8**										**5.5**		
Buffalo	767	247	280	29.30	30.16	+ .09	23.2	− 1.5	52	4	30	3	23	16	23	21	17	76	1.44	− 1.9	9	15,494	w.	76	sw.	22	4	7	20	7.4	9.6	1.7
Canton	448	10	61	29.64	30.15	.....	12.8	− 3.5	45	5	22	−17	25	4	32	.....	.....	.....	1.82	− 1.3	14	9,242	w.	52	w.	22	14	7	10	4.5	15.8	5.2
Oswego	335	76	91	.....	30.17	+ .10	20.2	− 3.7	45	5	28	− 8	26	13	29	.....	.....	.....	1.40	− 1.8	11	9,992	s.	52	nw.	11	8	3	20	.....	24.6	5.7
Rochester	523	86	102	29.58	30.18	+ .11	22.6	− 1.4	51	5	30	− 3	26	16	25	19	13	66	2.41	− 0.7	13	7,632	w.	44	w.	22	6	9	16	6.8	25.5	6.0
Syracuse	597	97	113	29.51	30.18	+ .11	20.2	− 2.8	50	5	28	− 8	26	13	30	.....	.....	.....	3.54	+ 1.4	16	9,029	s.	51	nw.	22	5	11	15	6.8	31.6	4.0
Erie	714	130	166	29.37	30.17	+ .09	25.7	− 0.8	55	4	32	5	25	19	24	23	17	70	1.97	− 1.1	11	12,323	w.	63	se.	14	8	13	10	5.8	9.0	T.
Cleveland	762	190	201	29.34	30.20	+ .11	25.6	− 0.6	56	4	33	2	25	19	26	22	17	71	1.52	− 0.9	9	10,238	w.	46	w.	15	9	9	13	6.0	7.3	T.
Sandusky	629	62	103	29.48	30.19	+ .10	25.8	− 0.5	56	4	33	3	23	19	28	.....	.....	.....	1.29	− 0.8	6	10,094	sw.	44	sw.	14	12	11	8	4.5	4.5	0.0
Toledo	628	208	243	29.49	30.21	+ .12	24.4	− 1.2	55	4	32	1	24	17	32	21	16	73	1.54	− 0.4	6	11,674	sw.	51	sw.	5	14	10	7	4.1	7.0	0.5
Fort Wayne	856	113	124	29.25	30.22	.....	22.9	− 4.0	56	4	32	− 6	25	14	35	20	16	79	1.72	.....	8	7,813	sw.	42	sw.	4	12	8	11	5.1	11.4	2.5
Detroit	730	218	245	29.36	30.19	+ .11	23.8	− 0.5	52	4	32	0	23	16	29	21	17	76	1.58	− 0.4	8	9,466	sw.	48	w.	5	15	8	8	4.4	5.9	T.
Upper Lake Region.							**18.1**	**− 0.2**										**80**	**1.23**	**− 0.8**										**6.0**		
Alpena	609	13	92	29.45	30.15	+ .11	19.4	+ 0.7	38	9	28	− 8	25	11	35	17	13	82	1.13	− 1.1	9	9,122	sw.	45	nw.	22	10	6	15	5.5	15.5	3.9
Escanaba	612	54	60	29.45	30.15	+ .10	14.7	+ 0.2	38	9	24	−17	25	6	32	13	10	86	1.12	− 0.4	7	7,338	nw.	38	ne.	4	11	8	12	4.9	11.9	7.0
Grand Haven	632	54	89	29.46	30.18	+ .11	23.2	− 1.3	45	4	30	− 3	25	16	29	21	17	77	1.39	− 1.4	16	9,981	w.	60	w.	22	6	10	15	6.5	11.6	0.1
Grand Rapids	707	70	87	29.39	30.19	+ .13	23.6	− 0.2	50	4	31	2	22	16	28	20	16	76	0.71	− 2.1	10	5,152	w.	32	w.	22	6	9	16	6.7	5.4	T.
Houghton	684	62	99	29.36	30.12	+ .07	13.4	− 1.1	36	31	21	−20	25	5	43	.....	.....	.....	2.79	+ 0.8	16	7,478	e.	42	w.	19	6	3	22	7.7	28.5	19.8
Lansing	878	11	62	29.19	30.17	.....	21.0	− 1.0	48	4	30	−12	25	12	31	18	15	83	1.23	− 0.9	13	5,498	sw.	27	sw.	4	7	10	14	5.8	5.9	T.
Ludington	637	60	66	29.43	30.16	.....	22.4	.....	41	4	29	1	22	16	23	20	17	80	0.56	.....	10	9,450	w.	54	w.	21	7	9	15	6.5	6.5	0.5
Marquette	734	77	111	29.30	30.14	+ .10	17.2	+ 1.3	38	31	24	−13	23	10	31	14	11	80	1.94	− 0.1	14	9,187	sw.	50	se.	14	9	5	17	6.5	22.2	15.9
Port Huron	638	70	120	29.44	30.17	+ .11	22.2	+ 0.4	51	4	30	− 3	23	14	27	20	17	81	1.10	− 0.8	7	9,335	nw.	45	w.	22	13	11	7	4.5	6.8	T.
Saginaw	641	60	77	29.46	30.18	.....	21.8	.....	46	4	30	− 5	25	14	30	19	16	81	0.92	− 1.3	9	7,010	sw.	35	sw.	4	7	10	14	5.9	6.1	0.2
Sault Sainte Marie	614	11	52	29.41	30.15	+ .12	12.1	− 1.2	35	8	21	−20	25	3	33	11	9	90	1.44	− 0.7	16	5,315	se.	48	nw.	22	2	9	20	7.8	16.0	17.0
Chicago	823	140	310	29.28	30.20	+ .10	24.8	+ 1.1	52	4	32	− 1	22	17	37	22	16	68	1.16	− 0.8	9	9,688	sw.	42	sw.	4	12	10	9	4.7	2.0	0.0
Green Bay	617	100	144	29.47	30.17	+ .11	13.0	− 1.6	37	9	22	−20	24	4	41	12	9	82	0.88	− 0.8	5	8,806	sw.	48	w.	21	7	9	15	6.3	10.8	4.0
Milwaukee	681	125	139	29.41	30.18	+ .10	21.6	+ 1.8	45	31	29	− 7	23	14	32	18	12	66	0.92	− 1.1	5	8,888	sw.	31	sw.	4	12	13	6	4.2	1.5	0.0
Duluth	1,133	11	47	28.85	30.15	+ .06	8.6	− 1.8	36	9	17	−30	23	1	38	7	5	89	0.51	− 0.5	10	10,488	sw.	53	nw.	14	10	6	15	6.0	5.5	4.8
North Dakota.							**7.1**	**+ 3.0**										**85**	**0.46**	**− 0.2**										**5.9**		
Moorhead	940	50	58	29.09	30.17	+ .03	8.4	+ 5.7	35	9	18	−29	23	−2	35	7	3	83	0.42	− 0.3	11	7,163	s.	32	n.	21	9	6	16	6.2	4.2	2.3
Bismarck	1,674	8	57	28.28	30.17	+ .04	8.4	+ 1.7	40	9	19	−32	23	−2	41	7	4	85	0.[illegible]4	− 0.2	6	6,683	nw.	44	nw.	14	11	9	11	5.5	3.9	6.3
Devils Lake	1,482	11	44	28.43	30.11	− .01	4.1	+ 3.8	33	9	15	−35	23	−6	38	3	1	88	0.58	0.0	11	7,585	w.	39	n.	14	9	10	12	5.4	6.3	5.7
Ellendale	1,457	10	56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grand Forks	835	12	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Williston	1,878	41	48	28.02	30.11	.00	7.4	+ 0.9	38	9	18	−36	23	−3	42	6	4	84	0.51	− 0.1	11	5,490	w.	37	nw.	14	10	4	17	6.4	5.0	5.1
Upper Mississippi Valley.							**22.2**	**+ 0.6**										**76**	**1.17**	**− 0.5**										**5.1**		
Minneapolis	918	102	208	29.11	30.14	.....	13.8	.....	39	9	22	−18	22	6	42	.....	.....	.....	0.88	+ 0.2	7	9,378	s.	41	nw.	21	8	11	12	6.2	7.0	2.4
St. Paul	837	236	261	29.23	30.19	+ .08	12.8	+ 1.2	40	9	21	−20	24	4	42	.....	.....	.....	0.90	0.0	7	9,422	se.	52	nw.	21	10	12	9	5.2	8.0	2.7
La Crosse	714	11	48	29.38	30.20	+ .09	14.0	− 1.2	42	9	24	−24	24	4	39	.....	.....	.....	1.25	+ 0.2	4	3,920	s.	24	w.	14	12	6	13	5.5	13.8	3.0
Madison	974	70	78	29.10	30.22	+ .12	17.0	+ 0.5	41	31	26	−12	24	8	34	14	12	82	0.63	− 0.9	3	7,404	nw.	35	sw.	21	12	10	9	4.5	1.5	T.
Wausau	1,247	4	.....	28.77	30.19	.....	10.8	.....	36	31	20	−32	24	1	39	.....	.....	.....	0.77	.....	7	.....	nw.	.....	.....	.....	8	11	12	6.1	8.5	13.5
Charles City	1,015	10	49	29.07	30.21	+ .07	13.2	+ 1.8	38	2	23	−29	6	3	37	11	9	87	1.44	+ 0.5	8	5,295	se.	30	nw.	14	10	10	11	5.8	20.5	4.3
Davenport	606	71	79	29.53	30.23	+ .11	23.0	+ 2.2	50	31	32	− 5	24	14	30	19	13	70	0.98	− 0.6	2	6,019	e.	26	nw.	4	16	8	7	4.0	1.0	0.0
Des Moines	861	84	97	29.23	30.19	+ .05	22.6	+ 2.2	49	9	31	− 5	24	14	28	20	15	76	0.85	− 0.4	7	6,039	se.	35	sw.	16	14	7	10	4.8	3.2	T.
Dubuque	698	81	96	29.43	30.23	+ .11	19.7	+ 1.4	42	9	28	− 9	24	11	35	17	12	75	1.16	− 0.3	5	5,026	nw.	25	nw.	21	17	6	8	3.8	2.8	0.0
Keokuk	614	64	78	29.52	30.24	+ .10	25.3	+ 1.6	55	3	34	1	23	16	39	21	15	66	1.04	− 0.6	5	5,848	e.	35	w.	4	13	11	7	4.6	3.5	0.0
Cairo	356	87	93	29.81	30.21	+ .05	34.3	− 0.5	64	4	42	15	24	27	30	31	26	74	1.48	− 2.3	8	7,468	n.	42	n.	11	6	8	17	6.7	4.0	0.0
Peoria	600	11	45	29.53	30.23	+ .11	23.8	+ 0.7	54	4	34	− 4	24	14	44	20	18	87	1.69	− 0.5	6	5,661	s.	31	sw.	4	14	10	7	4.2	2.8	0.0
Springfield, Ill	644	10	91	29.50	30.21	+ .08	25.2	− 1.1	56	4	34	− 4	23	17	43	21	17	78	1.83	− 0.4	7	6,395	ne.	29	s.	2	15	8	8	4.2	7.1	T.
Hannibal	534	74	109	29.63	30.23	+ .10	27.1	+ 0.4	57	3	36	1	23	18	40	.....	.....	.....	1.56	− 0.6	6	6,570	sw.	33	sw.	14	11	9	11	5.1	4.3	T.
St. Louis	567	265	303	29.58	30.21	+ .07	30.2	− 0.8	61	14	38	3	23	22	41	26	20	68	0.74	− 1.5	6	8,919	s.	48	sw.	4	11	10	10	5.2	4.1	0.0
Missouri Valley.							**23.2**	**+ 2.2**										**78**	**1.09**	**+ 0.1**										**5.1**		
Columbia, Mo	781	11	84	29.34	30.21	+ .08	28.4	+ 1.2	63	3	37	− 3	23	19	42	.....	.....	.....	1.53	− 0.7	4	6,419	e.	33	sw.	4	13	10	8	4.6	4.3	0.0
Kansas City	963	161	181	29.12	30.20	+ .05	29.7	+ 3.5	64	3	38	1	23	21	46	25	18	63	0.61	− 0.5	6	8,389	nw.	39	n.	10	15	4	12	4.8	1.4	0.0
St. Joseph	967	11	49	29.10	30.18	.....	27.8	.....	56	9	37	1	19	19	31	23	18	73	0.55	.....	5	6,607	se.	36	nw.	4	15	8	8	4.3	1.1	0.0
Springfield, Mo	1,324	98	104	28.73	30.19	+ .05	31.8	+ 0.5	61	4	40	7	24	24	41	29	25	80	1.38	− 1.3	5	7,993	se.	31	w.	4	10	6	15	5.9	7.4	0.0
Iola	984	11	50	29.10	30.20	+ .06	30.0	+ 2.4	64	3	40	3	23	20	39	.....	.....	.....	0.96	0.0	6	5,432	s.	28	sw.	4	8	6	17	6.9	6.0	0.0
Topeka	987	92	107	.....	.....	.....	28.8	+ 3.2	62	9	38	2	19	19	33	.....	.....	.....	0.34	− 0.6	6	7,739	s.	40	n.	10	11	5	15	5.6	2.1	0.0
Drexel	1,299	10	53	28.72	30.17	.....	21.2	.....	49	9	31	−10	19	12	32	18	16	87	1.45	.....	6	9,051	nw.	41	sw.	16	12	11	8	4.7	10.9	3.2
Lincoln	1,189	11	84	28.85	30.18	+ .03	21.2	+ 3.0	55	9	34	− 7	19	14	34	21	17	79	1.13	+ 0.5	5	8,206	s.	33	nw.	14	13	5	13	5.3	6.4	T.
Omaha	1,105	115	122	28.95	30.19	+ .04	23.6	+ 3.1	50	2	32	− 5	19	15	30	20	15	70	0.94	+ 0.3	8	6,723	nw.	33	n.	4	14	10	7	4.3	6.2	0.5
Valentine	2,598	47	54	27.31	30.17	+ .05	16.8	− 1.4	53	1	28	−18	19	6	44	14	12	85	1.00	+ 0.5	9	7,564	w.	40	nw.	14	17	6	8	4.7	16.0	4.8
Sioux City	1,135	94	164	28.91	30.19	+ .04	19.2	+ 3.6	46	9	28	− 9	5	10	32	17	13	77	1.36	+ 0.8	6	9,494	nw.	47	nw.	14	15	4	12	5.3	11.2	2.5
Huron	1,306	50	74	28.72	30.20	+ .04	13.8	+ 4.3	42	9	23	−18	5	4	35	12	9	84	1.34	+ 0.8	9	7,798	se.	42	nw.	14	15	6	10	4.3	11.9	7.0
Pierre	1,572	70	75	28.42	30.18	+ .05	13.6	− 0.3	42	9	23	−17	23	4	42	11	8	79	0.68	+ 0.2	7	6,456	nw.	40	nw.	14	16	3	12	4.8	9.0	2.0
Yankton	1,233	49	57	28.80	30.19	+ .03	18.2	+ 2.7	46	2	28	−11	19	9	35	.....	.....	.....	1.77	+ 1.2	7	6,730	nw.	36	nw.	14	11	11	9	5.3	15.0	9.0

TABLE I.—*Climatological data for Weather Bureau stations, January, 1922*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max. + mean min. ÷ 2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope.							15.9	− 3.1										73	0.74	− 0.1										5.0		
Billings	3,140	5																														
Havre	2,505	11	44	27.38	30.14	+ .04	13.8	+ 0.3	49	13	24	−26	30	4	48	12	10	84	0.42	− 0.3	9	6,679	sw.	38	sw.	8	5	11	15	6.6	4.2	2.6
Helena	4,110	87	112	25.78	30.16	+ .01	19.6	− 0.4	48	1	27	−17	30	12	31	16	9	64	0.52	− 0.4	6	6,744	sw.	33	sw.	21	6	9	16	6.7	8.0	3.0
Kalispell	2,973	48	56	......	30.18	+ .06	16.9	− 2.7	42	9	24	12	18	10	21				0.74	− 0.8	10	3,048	nw.	22	sw.	9	7	4	20	......	8.9	6.5
Miles City	2,371	26	48	27.51	30.20	+ .08	13.8	− 0.7	43	9	22	−25	30	5	37	12	9	84	1.00	+ 0.4	11	5,234	se.	33	nw.	21	13	13	5	4.8	10.1	6.5
Rapid City	3,259	50	58	26.59	30.20	+ .10	16.8	− 4.7	50	13	28	−16	23	6	49	14	8	67	0.97	+ 0.5	9	5,869	n.	40	nw.	10	11	8	12	5.5	10.0	3.3
Cheyenne	6,088	84	101	23.89	30.10	+ .05	21.0	− 4.6	55	2	31	−22	18	11	36	17	8	58	0.47	+ 0.1	4	10,624	w.	71	w.	21	16	9	6	3.9	4.2	T.
Lander	5,372	66	68	24.58	30.26	+ .14	7.4	−10.0	39	2	20	−34	19	−6	46	4	− 1	78	1.13	+ 0.7	6	2,004	sw.	17	nw.	10	23	4	4	3.1	12.1	6.6
Sheridan	3,790	10	47	26.08	30.19	......	11.6	......	47	13	24	−29	30	−1	46	10	5	74	1.27	......	12	3,572	nw.	29	s.	9	14	7	10	4.7	13.3	10.6
Yellowstone Park	6,200	11	48	23.81	30.21	+ .07	12.5	− 5.1	39	1	21	−23	18	4	29	10	7	80	0.74	− 1.5	9	6,787	s.	27	n.	17	9	10	12	5.7	8.1	17.8
North Platte	2,821	11	51	27.12	30.19	+ .07	21.6	+ 0.2	58	2	35	−11	30	8	40	17	12	74	0.66	+ 0.2	6	6,106	w.	34	nw.	10	15	9	7	3.9	6.3	4.0
Middle Slope.							29.2	+ 0.2										69	0.59	− 0.1										4.9		
Denver	5,292	106	113	24.65	30.08	+ .03	27.7	− 1.4	61	2	39	−10	19	16	37	21	11	58	0.30	− 0.1	4	5,661	s.	36	w.	14	19	9	3	3.0	4.9	T.
Pueblo	4,685	80	86	25.23	30.08	+ .03	26.1	− 3.0	61	2	41	− 5	20	11	50	21	13	62	0.39	0.0	5	4,306	nw.	38	nw.	14	17	10	4	3.8	3.9	0.0
Concordia	1,392	50	58	28.65	30.18	+ .04	27.0	+ 2.6	57	9	37	0	19	17	36	22	18	77	0.38	− 0.3	5	7,017	s.	37	n.	12	10	8	13	5.7	0.9	0.0
Dodge City	2,509	11	51	27.47	30.18	+ .07	28.6	+ 1.3	69	2	40	− 1	19	17	40	24	19	74	0.45	0.0	5	7,425	s.	34	s.	29	15	8	8	4.4	0.2	0.0
Wichita	1,358	139	158	28.67	30.16	+ .03	30.8	+ 1.1	63	3	39	3	19	22	37	27	21	72	0.88	+ 0.1	7	9,029	s.	47	s.	2	9	6	16	6.5	0.8	0.0
Altus	1,410	5	......	......	......	......	37.2	......	69	3	47	12	19	27	40				0.89		5						14	1	16		0.0	0.0
Broken Arrow	765	11	52																													
Muskogee	652	4	......	......	......	......	37.8	......	66	14	47	13	19	29	35				2.23	......	7		se.				10	12	9		0.6	0.0
Oklahoma City	1,214	10	47	28.86	30.18	+ .07	35.2	+ 0.5	68	3	44	10	19	26	36	30	24	69	1.15	− 0.2	8	8,765	n.	39	s.	2	8	9	14	6.2	0.6	0.0
Southern Slope.							40.3	− 1.2										59	0.54	− 0.2										5.6		
Abilene	1,738	10	52	28.29	30.15	+ .06	41.3	− 1.3	75	3	51	16	19	31	43	34	25	66	1.18	+ 0.3	8	6,825	n.	44	sw.	2	7	5	19	7.0	T.	0.0
Amarillo	3,676	10	49	26.28	30.12	+ .06	34.0	+ 0.1	67	2	46	2	19	22	39	27	21	70	0.78	+ 0.2	8	8,666	se.	37	nw.	10	14	11	6	4.6	1.2	0.0
Del Rio	944	64	71	29.12	30.13	+ .07	48.8	− 1.4	70	14	58	25	13	39	44				0.15	− 0.7	3	5,766	se.	46	nw.	10	10	3	18	6.5	0.0	0.0
Roswell	3,566	75	85	26.38	30.07	+ .03	37.1	− 2.1	68	18	52	6	19	22	50	29	16	48	0.04	− 0.5	2	5,990	s.	38	sw.	31	16	7	8	4.2	T.	0.0
Southern Plateau.							37.7	− 3.0										53	0.78	0.0										3.2		
El Paso	3,762	110	133	26.20	30.03	+ .02	43.5	− 0.6	67	18	55	20	14	32	35	34	22	46	0.30	− 0.2	5	7,622	nw.	46	sw.	3	19	8	4	3.3	0.3	0.0
Santa Fe	7,013	57	66	23.16	30.06	+ .02	28.0	− 0.5	51	1	38	5	21	18	30	22	15	63	0.64	0.0	4	6,376	n.	36	se.	30	15	10	6	3.9	10.2	1.0
Flagstaff	6,908	10	59	23.26	30.04	− .01	21.3	− 5.4	52	1	35	−20	21	7	49	17	......		4.78	......	8	4,712	w.	36	s.	30	18	7	6	......	41.8	20.0
Phoenix	1,108	76	81	28.85	30.03	.00	48.6	− 1.4	69	13	62	24	21	36	38	40	30	55	1.29	+ 0.1	6	3,100	e.	22	w.	3	15	13	3	3.5	0.0	0.0
Yuma	141	9	54	29.91	30.06	+ .01	50.8	− 3.9	70	27	62	29	21	40	33	42	29	46	0.54	+ 0.1	6	5,385	n.	30	s.	30	18	10	3	3.3	0.0	0.0
Independence	3,957	9	41	26.00	30.12	+ .05	34.2	− 6.3	57	1	46	6	31	23	33	28	18	57	1.11	+ 0.2	3	4,940	nw.	40	sw.	17	24	4	3	1.8	10.1	8.0
Middle Plateau.							20.9	− 7.5										74	1.09	0.0										3.6		
Reno	4,532	74	81	25.50	30.21	+ .08	24.1	− 8.4	49	26	35	− 1	20	13	33	22	17	74	0.64	− 1.3	9	3,247	w.	39	w.	27	15	8	8	4.4	5.4	2.3
Tonopah	6,090	12	20	24.04	30.17	......	24.4	......	48	1	31	−10	19	18	28	22	16	70	1.04	+ 0.3	5	5,497	w.	43	w.	17	22	4	5	2.9	9.0	3.0
Winnemucca	4,344	18	56	25.69	30.28	+ .12	14.8	−14.0	39	1	29	−18	19	1	40	14	10	81	1.15	+ 0.1	7	4,853	ne.	34	nw.	27	15	7	9	4.2	10.5	8.8
Modena	5,479	10	43	24.59	30.17	+ .07	16.6	−10.9	47	1	31	−12	20	2	39	13	8	73	1.72	+ 1.0	7	6,105	w.	48	s.	30	20	6	5	2.6	14.6	6.2
Salt Lake City	4,360	163	203	25.69	30.21	+ .06	22.2	− 6.6	50	1	30	− 7	19	15	23	20	16	77	1.42	+ 0.1	10	4,356	se.	33	nw.	27	14	5	12	4.6	13.2	2.2
Grand Junction	4,602	60	68	25.41	30.09	+ .03	27.0	+ 2.3	59	2	38	5	21	16	31	22	16	68	0.58	+ 0.1	4	3,859	se.	30	s.	28	19	6	6	3.1	5.5	3.5
Northern Plateau.							20.3	− 8.5										83	1.06	− 0.6										7.2		
Baker	3,471	48	53	26.54	30.28	+ .12	14.4	− 9.5	36	1	24	−16	19	5	33	14	11	83	0.61	− 0.7	11	4,352	se.	21	nw.	17	7	8	16	6.0	10.1	2.0
Boise	2,739	78	86	27.32	30.30	+ .11	20.6	− 8.7	45	26	28	−10	19	13	31	20	16	77	0.90	− 1.0	7	3,326	w.	29	se.	26	9	3	19	6.9	9.5	1.5
Lewiston	757	40	48	29.40	30.24	+ .08	27.3	− 7.2	51	9	34	− 7	19	21	22				0.56	− 1.0	10	2,643	e.	21	ne.	8	6	8	17	6.8	5.9	T.
Pocatello	4,477	60	68	25.52	30.26	+ .06	16.0	− 9.1	41	1	24	−20	19	8	30	14	11	81	1.54	+ 0.9	10	6,141	se.	36	sw.	17	5	8	18	7.1	12.5	1.0
Spokane	1,929	101	110	28.09	30.23	+ .11	20.6	− 6.1	40	8	28	−12	18	14	28	20	18	86	1.19	− 1.1	13	3,128	nw.	23	sw.	26	1	6	24	8.4	13.7	8.0
Walla Walla	991	57	65	29.13	30.25	+ .10	23.0	−10.2	48	9	30	− 4	18	16	34	22	20	88	1.54	− 0.5	10	2,684	s.	20	se.	26	3	4	24	8.3	16.3	3.8
North Pacific coast region.							36.9	− 3.1										82	2.87	− 3.9										6.4		
North Head	211	11	56	29.90	30.13	+ .08	39.8	− 2.0	60	11	44	24	18	35	21	38	35	83	3.43	− 3.2	18	8,739	se.	64	s.	26	13	10	8	4.6	1.5	0.0
Port Angeles	29	8	53	30.15	30.17	......	35.8	......	50	25	41	22	31	30	15				1.59	− 3.9	12	4,657	s.	38	n.	16	6	10	15	6.5	2.0	0.0
Seattle	125	215	250	30.04	30.18	+ .13	35.5	− 3.8	50	8	40	16	18	31	16	34	32	85	1.89	− 3.0	12	7,052	se.	45	s.	26	6	7	18	6.9	2.6	0.0
Tacoma	213	113	120	29.96	30.19	+ .15	34.4	− 3.7	54	8	40	12	18	29	19				1.72	− 4.1	13	5,021	sw.	39	ne.	30	3	8	20	7.7	1.3	0.0
Tatoosh Island	86	7	57	30.01	30.11	+ .13	39.5	− 1.7	49	12	43	28	30	36	10	37	35	83	4.68	− 7.5	19	13,850	e.	61	s.	26	9	5	17	6.3	0.0	0.0
Yakima	1,071	4																														
Medford	1,425	4																														
Portland, Oreg.	153	68	106	30.02	30.18	+ .10	35.2	− 3.9	52	25	40	16	18	30	17	33	29	78	3.08	− 3.4	16	3,945	e.	26	s.	26	6	4	21	7.4	1.7	0.0
Roseburg	510	9	57	29.62	30.19	+ .09	37.2	− 3.6	56	24	44	14	19	30	23	35	32	83	3.68	− 2.0	16	1,836	s.	14	w.	1	5	18	8	5.7	2.4	0.0
Middle Pacific coast region.							43.8	− 3.7										72	2.20	− 2.3										4.2		
Eureka	62	73	89	30.11	30.18	+ .08	43.2	− 3.7	59	12	50	25	19	36	21	41	37	77	2.54	− 5.1	16	4,159	se.	39	n.	6	9	8	14	5.6	T.	0.0
Point Reyes Light	490	7	18	29.56	30.08	......	47.6	− 1.8	64	13	52	31	19	43	20				2.06	......	11	13,474	nw.	84	nw.	1	15	10	6	3.9	0.1	0.0
Red Bluff	332	50	56	29.77	30.14	+ .02	41.9	− 3.5	65	11	52	22	21	32	34	38	30	66	1.41	− 2.5	7	4,086	nw.	40	nw.	18	16	10	5	3.8	T.	0.0
Sacramento	69	106	117	30.06	30.14	+ .02	40.6	− 5.0	58	26	47	26	21	34	24	39	35	78	2.16	− 1.5	7	4,906	se.	48	nw.	18	13	10	8	4.4	1.5	0.0
San Francisco	155	208	243	29.95	30.12	+ .01	46.8	− 2.7	61	12	53	32	19	41	28	42	36	69	2.41	− 1.9	6	6,397	nw.	43	ne.	19	18	8	5	3.7	T.	0.0
San Jose	141	12	110	29.97	30.13	......	42.9	− 5.4	62	25	54	23	21	32	32				2.46	− 0.4	8	4,203	n.	29	ne.	19	17	8	6	3.7	0.0	0.0
South Pacific coast region.							49.0	− 2.1										66	3.76	+ 1.0										4.0		
Fresno	327	89	98	29.77	30.14	+ .04	41.7	− 3.7	60	26	49	24	19	34	25	38	34	77	2.46	+ 0.9	7	3,889	nw.	29	nw.	2	12	8	11	4.8	T.	0.0
Los Angeles	338	159	191	29.69	30.06	− .02	53.4	− 0.9	77	13	62	31	20	44	29	45	37	58	4.64	+ 1.8	6	4,686	ne.	33	e.	29	18	8	5	3.5	0.0	0.0
San Diego	87	62	70	29.95	30.05	− .02	52.5	− 1.5	72	12	60	35	21	45	23	47	41	68	3.45	+ 1.4	10	5,011	nw.	52	s.	30	15	8	8	4.4	0.0	0.0
San Luis Obispo	201	32	40	29.87	30.10	+ .01	48.6	− 2.4	70	11	61	24	20	36	42	41	33	61	4.48	− 0.2	8	3,018	n.	27	ne.	19	15	11	5	3.5	0.0	0.0
West Indies.																																
San Juan, P. R.	82	8	54	29.94	30.03	......	74.4	......	82	27	79	66	9	70	15				5.37	+ 0.8	21	10,865	e.	42	e.	14	11	13	7	5.2	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97																													
Colon	25	5	71																													
Alaska.																																
Juneau	80	11	49	......	......	......	31.5	......	42	11	34	15	30	29	11	30	26	82	11.56	......	21	3,538	se.	20	ne.	17	4	2	25	8.5	12.7	T.

TABLE II.—*Data furnished by the Canadian Meteorological Service, January, 1922.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure. Station reduced to mean of 24 hours.	Pressure. Sea level reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Mean maximum.	Temperature of the air. Mean minimum.	Temperature of the air. Highest.	Temperature of the air. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	°*F*	°*F*	°*F*	°*F*	°*F*	°*F*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	29.92	29.97	+0.04	20.5	0.0	28.4	12.7	46	−12	5.80	+0.70	52.0
Halifax, N. S.	88	29.91	30.02	+ .05	21.1	− 0.7	29.7	12.4	46	−11	2.96	−2.81	17.3
Yarmouth, N. S.	65	29.97	30.04	+ .04	25.3	− 1.0	31.5	19.1	48	0	2.81	−2.60	13.2
Charlottetown, P. E. I.	38	29.95	29.99	+ .03	16.8	− 0.2	24.7	9.0	42	−14	3.59	−0.37	20.7
Chatham, N. B.	28	30.01	30.05	+ .08	11.0	+ 1.2	22.8	− 0.8	38	−27	2.36	−1.23	22.6
Father Point, Que.	20	30.10	30.13	+ .13	8.4	+ 0.4	17.5	− 0.6	32	−18	2.78	−0.07	27.8
Quebec, Que.	296	29.78	30.13	+ .11	9.4	+ 0.3	17.6	1.3	36	−19	2.44	−1.57	23.4
Montreal, Que.	187	29.92	30.15	+ .11	12.8	+ 1.1	19.7	5.9	39	−12	2.36	−1.37	20.6
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.89	30.18	+ .15	11.9	+ 2.3	22.7	1.1	40	−19	1.81	−1.18	18.1
Kingston, Ont.	285	29.83	30.17	+ .12	17.2	+ 0.1	25.2	9.3	42	−11	1.21	−2.24	5.4
Toronto, Ont.	379	29.74	30.17	+ .12	23.2	+ 1.8	30.1	16.4	46	− 1	1.38	−1.54	9.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.68	30.08	+ .07	1.1	+ 1.5	15.2	−13.0	35	−47	1.24	−0.45	12.4
Port Stanley, Ont.	592	29.52	30.19	+ .12	22.6	+ 0.4	31.6	13.7	48	− 6	1.93	−1.06	1.4
Southampton, Ont.	656	29.39			19.6	− 0.8	27.1	12.0	37	− 7	2.97	−1.08	26.3
Parry Sound, Ont.	688	29.38	30.12	+ .11	15.2	+ 1.4	25.4	5.1	40	−14	4.80	+0.72	45.8
Port Arthur, Ont.	641	29.38	30.13	+ .06	7.3	+ 4.2	16.8	− 2.2	31	−27	0.45	−0.37	4.5
Winnipeg, Man.	760	29.23	30.13	+ .02	3.0	+ 9.8	12.0	− 6.0	35	−38	0.27	−0.61	2.7
Minnedosa, Man.	1,690	28.16	30.10	.00	0.6	+ 7.8	11.1	− 9.8	32	−41	0.28	−0.52	2.8
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.67	30.05	− .03	3.8	+ 7.6	14.0	− 6.3	39	−40	0.43	−0.07	4.3
Medicine Hat, Alb.	2,144	27.66	30.02	− .05	15.6	+10.1	25.0	6.2	45	−24	0.53	−0.04	5.3
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.41	30.18	+ .09	10.8	+ 7.7	20.7	1.0	41	−48	0.81	+0.17	8.1
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.30	30.14	+ .14	8.7	− 3.4	18.5	− 1.2	39	−36	0.97	−0.22	9.7
Edmonton, Alb.	2,150	27.60	30.00	+ .03	10.1	+ 8.3	20.0	0.4	47	−50	0.75	−0.07	7.4
Prince Albert, Sask.	1,450	28.39	30.06	− .03	2.0	+10.4	11.7	− 7.6	42	−40	0.64	−0.33	6.4
Battleford, Sask.	1,592	28.20	30.05	− .03	2.5	+ 8.4	12.9	− 7.8	43	−43	0.20	−0.20	2.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.89	30.15	+ .18	36.3	− 2.2	39.9	32.7	47	21	2.77	−2.62	7.7
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.98	30.15	+ .02	61.7	− 0.3	67.6	55.9	76	45	5.95	+1.01	0.0

SEISMOLOGICAL REPORTS FOR JANUARY, 1922.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, March 3, 1922.]

SEISMOLOGICAL ABBREVIATIONS USED IN THE INSTRUMENTAL REPORTS.

CHARACTER OF THE EARTHQUAKE.

I=noticeable.
II=conspicuous.
III=strong.
d=(terræ motus domesticus)=local earthquake (sensible or felt).
v=(terræ motus vicinus)=near-by earthquake (within 1,000 km).
r=(terræ motus remotus)=distant earthquake (1,000 to 5,000 km. distant).
u=(terræ motus ultimus)=very distant earthquake (beyond 5,000 km.).
Δ=distance to epicenter.

PHASES.

P=(undæ primæ)=first preliminary tremors.
PR_n=P waves reflected *n* times at the earth's surface.
S=(undæ secundæ)=second preliminary tremors.
SR_n=S waves reflected *n* times at the earth's surface.
PS=transformed waves; longitudinal (P) to transverse (S) or vice versa.
L=(undæ longæ)=long waves in the principal portion.
M=(undæ maximæ)=greatest motion in the principal portion.
C=(coda)=trailers.
O=time at epicenter.
L_{rep_1}=long waves reaching the station from the antiepicenter (40,000 km. $-\Delta$).
L_{rep_2}=long waves again reaching the station from the antiepicenter (40,000 km. $+\Delta$).
F=(finis)=end of perceptible trace.

NATURE OF THE MOTION.

i=(impetus)=abrupt beginning.
e=(emersio)=gradual appearance.
T=(period)=twice time of oscillation.
A=amplitude of earth's movement, reckoned from the zero line. E, N, or Z attached to a symbol signifies the E-W, the N-S, or the vertical component, respectively, thus:
P_E is the E-W component of P.
P_N is the N-S component of P.
P_Z is the vertical component of P.
μ=micron, $\frac{1}{1000}$ mm.

INSTRUMENTAL CONSTANTS.

T_0=period of instrument.
V=magnification of instrument.
ϵ=damping ratio.

List of instrumental stations from which reports are received.

Location.	Latitude, N.	Longitude, W.	Elevation, meters.	Description of instruments.	Instrumental constants. E-W. V	Instrumental constants. E-W. T_0	Instrumental constants. E-W. ε	Instrumental constants. N-S. V	Instrumental constants. N-S. T_0	Instrumental constants. N-S. ε	Institution.	Director.
ALABAMA.	° ′ ″	° ′ ″										
Mobile	30 41 44	88 08 46	60	Wiechert 80-kg., two comp. inverted pendulum.	......	......	......	......	......	......	Spring Hill College, Seismic Observatory.	Cyril Ruhlmann, S. J.
ALASKA.												
Sitka	57 03	135 20 06	15.2	Bosch-Omori 10-kg., horizontal pendulum, two comp.	10	22	......	10	17.7	......	U. S. Coast and Geodetic Survey, Magnetic Observatory.	A. K. Ludy.
ARIZONA.												
Tucson	32 14 48	110 50 06	769.6	...do	10	17	......	10	17	......	...do	Wm. H. Cullum.
CALIFORNIA.												
Point Loma	32 43 03	117 15 10	91.4	Two-component C.D. West seismoscope.	......	......	......	......	......	......	Theosophical University, Meteorological Station.	F. J. Dick.
COLORADO.												
Denver	39 40 36	104 56 54	1,655	Wiechert 80-kg., inverted pendulum.	......	......	......	......	......	......	Regis College, Earthquake Station.	A. W. Forstall, S. J.
DISTRICT OF COLUMBIA.												
Washington	38 54 25	77 04 24	42.4	Wiechert 200-kg., inverted pendulum; *80-kg. vertical.*	165	5.4	0	142	5.2	0	Georgetown University, Seismological Station.	F. A. Tondorf, S. J.
					VERTICAL: *V, 80; T_0, 3.0.*							
				Bosch photographic pendulums (horizontal), 200 g.	133	5.0	......	133	5.0	......		
				Mainka bifilar pendulums, 135-kg., horizontal.	47	9.0	......	59	9.0	......		
				Bosch-Omori 25-kg., horizontal.	13.7	8.8	......	13.5	8.6	......		
Washington	38 54 12	77 03 03	21	Marvin, inverted pendulum, undamped, mechanical registration.	110	6.4	([3])	110	6.4	......	U. S. Weather Bureau	W. J. Humphreys.
HAWAII.												
Honolulu	21 19 12	158 03 48	15.2	Milne-Shaw	150	12	......	150	12	......	U. S. Coast and Geodetic Survey, Magnetic Observatory.	H. E. McComb.
ILLINOIS.												
Chicago	41 47	87 37	180.1	Two Milne-Shaw horizontal pendulums, 0.45-kg.	150	12	[2] 20:1	150	12	[2] 20:1	U. S. Weather Bureau, University of Chicago.	H. J. Cox.
MARYLAND.												
Cheltenham	38 44	76 50 30	*ca.* 71.6	Two Bosch-Omori 10-kg.	10	15	......	10	15	......	U. S. Coast and Geodetic Survey, Magnetic Observatory.	George Hartnell.
MASSACHUSETTS.												
Cambridge	42 22 36	71 06 59	5.4	Two Bosch-Omori 100-kg., horizontal pendulum, mechanical registration.	80	23	1.5	50	25	[4] 1.5	Harvard University Seismographic Station.	J. B. Woodworth.
MISSOURI.												
St. Louis	38 38 17	90 13 58.3	160.4	Wiechert 80-kg., inverted pendulum.	80	7	5:1	......	......	......	St. Louis University, Geophysical Observatory, Earthquake Station.	Geo. E. Rueppel.
NEW YORK.												
Ithaca	42 26 58	76 29 09	242.6	Bosch-Omori 25-kg., horizontal pendulum, mechanical registration.	12	21	4:1	13	24	4:1	Cornell University, Department of Geology, Seismograph Station.	P. S. Sheldon.
New York	40 51 47	73 53 08	23.9	Wiechert 80-kg., inverted pendulum.	80	70	5	80	70	5	Fordham University, Seismologic Station.	J. J. Lynch, S. J.
CANAL ZONE.												
Balboa Heights	8 57 39	79 33 29	*ca.* 36	Two Bosch-Omori 100-kg. and 25-kg.	{35 10	}20	......	{35 10	}20	......	Panama Canal, Department Operation and Maintenance, section of meteorology and hydrography, Seismologic Station.	R. Z. Kirkpatrick, chief hydrographer.
PORTO RICO.												
Vieques	18 08 50	65 26 50	19.1	Bosch-Omori 10-kg.	10	12.7	......	10	15.8	......	U. S. Coast and Geodetic Survey, Magnetic Observatory.	R. R. Bodle.
VERMONT.												
Northfield	44 10	72 41	256	Bosch-Omori, mechanical registration, 25 kg.	10	15	......	10	16	......	Local office, U. S. Weather Bureau.	Wm. A. Shaw.
CANADA.												
Ottawa	45 23 38	75 42 57	83	Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80-kg. vertical seismograph.	120	26	......	......	......	......	Dominion Observatory, Earthquake Station.	E. A. Hodgson.
Toronto	43 40 01	79 23 54	113.7	Milne horizontal pendulum, North, in the meridian.	......	18	[1] 0″.45	......	......	......	Dominion Meteorological Service.	
Victoria	48 24	123 19	67	Milne horizontal pendulum, North, in meridian.	......	18	[1] 0″.54	......	......	......	...do	

[1] Pillar inclination, 1 mm. [2] 1″ arc tilt, 26.6 mm. [3] 1 mm.=4″. [4] 15 mm.=60 sec.

For the reports of the stations at the University of California, Berkeley, Calif., and at the Lick Observatory, Mount Hamilton, Calif., see *Bulletin of the Seismographic Stations, University of California;* for the report of the station at the University of Santa Clara, Santa Clara, Calif., see *Record of the Seismographic Station, University of Santa Clara.*

SEISMOLOGICAL REPORTS FOR JANUARY, 1922.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, Mar. 3, 1922.]

TABLE 1.—*Noninstrumental earthquake reports, January, 1922.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1922.	H. m.		° ′	° ′			Sec.			
Jan. 1	1 10	Petaluma	38 15	122 38	5	3		None	Felt by many	John Landis.
26	5 25	Calexico	32 41	115 30	3	1	½	Faint	Felt by several	W. S. Pratt.
27	5 25	...do	32 41	115 30	3	1	2	Rumbling	...do	Do.
27	7 50	...do	32 41	115 30	4	1	3	Loud	Awakened sleepers	Do.
27	18 11	...do	32 41	115 30	3	1	1	None	Felt by many; abrupt	Do.
27	8 03	...do	32 41	115 30	2	1	1	Very loud	Felt by several	Do.
30	7 55	Brawley	32 59	115 40		1		None		M. D. Witter.
31	1 03	Calexico	32 41	115 30	3	2	½	Faint	Felt by several	W. S. Pratt.
31	13 15	Redding	40 35	122 25	4	1		None	...do	Parker Talbot.
		San Francisco	37 48	122 26	3	2		...do	...do	U. S. Weather Bureau.
		Willows	34 03	118 15					Felt by few	J. T. McLenon.
	13 17	Eureka	40 48	124 10	6	4	40, 1, 1, 1	None	Stopped clocks	J. M. Jones.
	13 20	Fort Bragg	39 30	123 50	3	2	5–6	...do	Felt by several	N. F. Fuller.
		Grass Valley	39 15	121 00	3	2		...do	...do	Mrs. L. M. Wentworth.
		McCloud	41 15	122 10	3	1		...do	...do	M. C. Gerlicher.
	13 25	Red Bluff	40 10	122 15	5?	3		Faint	Felt by many	H. J. Andree.
	13 40?	Cloverdale	38 45	123 00		1			Slight	J. O. Ogle.
		IDAHO.								
24	17 ..	Bennett	43 20	115 30	1	1	1	None	Felt by one	Mrs. R. Baxter.
		INDIANA.								
11	3 42	Mount Vernon	38 00	88 00	5	1	15–20	...do	Felt by many	G. B. Green
		SOUTH DAKOTA.								
2	14 50	Chamberlain	43 45	99 20	5					United Press.
		WASHINGTON.								
31	14 30	Tonasket	48 45	119 30	3?			Faint	Felt by several	G. A. Wallace.
	19 ca?	Republic	48 40	118 40	2	1	Brief.	None	...do	W. G. C. Lanskail.
		Clearbrook	49 00	122 10					Felt by two	R. D. Perry.

LATE REPORTS.

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
Dec. 4	16 57	Lakeport	39 00	123 00	3	1	1	None	Felt by several	J. Overholser.
		TENNESSEE.								
15	14 30	Rockwood	35 50	84 40	4–5	2	30	Loud	Felt by many	H. F. Ruter.
	14 50	Athens	35 20	84 35	4–5	1	180 ca.	Rumbling	...do	J. B. Elliott.
		Decatur	35 32	84 50	4	2–3	2	...do	...do	J. W. Linord.
	15 ca.	Dayton	35 20	85 00	4	1	Few.	...do	...do	W. F. Weir.
		Spring City	35 40	84 50	4			...do	Felt by several	H. M. Broyle.

TABLE 2.—*Instrumental seismological reports, January, 1922.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

Date.	Character.	Phase.	Time.	Period T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 5	....	L_E	9 08 27	13				No record on N.
		M_E	9 09 06	10	10			
		C_E	9 09 19					
		F_E	9 13 ..					
17	....	e_E	4 03 47					
		e_N	4 01 56					
		iS	4 10 51					
		M	4 10 55		150	200		
		C_E	4 15 ..					
		C^N	4 12 ..					
		F_N	4 22 ..					
		F_E	4 42 ..					
22	....	L_E	4 00 46	28				Do.
		M_E	4 10 00	15	20			
		C_E	4 16 ..					
		F_E	4 21 ..					
26	....	eL_E	9 38 07	24				Do.
		M_E	9 38 44	16	10			
		F_E	9 46 ..					
31	....	iP	13 21 30					
		L_E	13 24 52					
		L_N	13 24 58	24				
		M_E	13 26 02	17	3,040			
		M_N	13 26 41	12		440		
		M_N	13 29 14			450		
		C_E	13 27 ..					
		C_N	13 33 ..					
		F_E	14 40 ..					
		F_N	14 24 ..					

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

Date.	Character.	Phase.	Time.	Period T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 17	....	P_E	3 58 53	3				N not in operation during January.
		L_E	4 07 30	26				
		M_E	4 07 45	24	250			
		C_E	4 10 ..					
		F_E	5 01 ..					
20	....	e_E	2 14 47					
		M_E	2 15 35	10	10			
		C_E	2 16 33					
		F_E	2 23 ..					
20	....	C_E	4 31 23	3				
		L_E	4 31 36	11				
		M_E	4 31 54	8	50			
		C_E	4 33 ..	7				
		F_E	4 43 ..					
22	....	L_E	....	23				Record lost from 3:55 to 4:02.
		C_E	4 08 ..					
		F_E	4 31 ..					
22	....	L_E	21 21 19	29				
		M_E	21 26 16	18	20			
		C_E	21 43 ..	17				
		F_E	21 48 ..					
26	....	iP_E	9 35 03	4				A series of L waves, period 10 sec., begins at 9:26:47.
		S_E	9 38 31					
		eL_E	9 40 04	18				
		M_E	9 46 55	9	30			
		C_E	9 48 35	7				
		F_E	10 02 ..					
31	....	iP_E	13 20 59					*Stylus off paper from 13:26:03 to 13:29:39.
		S_E	13 24 07					Recorded on magnetograph from 13:22 to 13:35.
		L_E	13 24 41	30				
		M_E	(*)	16	4,200+			
		C_E	13 34 27	10				
		F_E	15 88 ..					

COLORADO. *Regis College, Denver.*

Date.	Character.	Phase.	Time.	Period T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 31	....	P	13 20 ..					Second preliminaries not visible.
		L	13 25 ..	3-7				
		M	13 27 ..	10	*67,000	*59,000		
		C	13 43 ..	8				
		F	14 29 ..					

* Trace amplitude.

92665—22——4

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 1	....	L_E	20 40 36	22				Very heavy microseisms.
		L_N	20 45 26					
		L_E	20 50 00					
		F	21 20 ..					
6	....	P_E?	14 20 43					Microseisms. No distinct *M*.
		P_N	14 20 43					
		S_E	14 20 32					
		S_N	14 28 31					
		eL_E	14 37.00	30				
		L_E	14 45 ..	22				
		L_N	14 46 06	16				
		F	15 30 ..					
9	....	eP_E	5 15 47					Do.
		eP_N	5 15 47					
		iS_E	5 21 05					
		eS_N	5 21 05					
		eL_E	5 24 12	21				
		F	6 (*ca*)					
17	....	eP_E	3 57 37					
		iP_N	3 57 40					
		i_E	3 59 33					
		i_E	4 00 51					
		iS_E	4 03 26					
		iS_N	4 03 28					
		eL_E	4 07 24	7				
		eL_N	4 07 36	6				
		M_{E1}	4 08 31			*6,700		
		M_{N1}	4 08 45		*4,300			
		M_{E2}	4 09 34			*5,000		
		M_{N2}	4 09 40		*4,600			
		M_{E3}	4 10 40			*4,100		
		M_{N3}	4 10 54		*3,900			
		M_{E4}	4 11 07			*5,500		
		M_{N4}	4 13 02		*1,900			
		M_{E5}	4 12 12			*3,800		
		F	4 50 ..					
			VERTICAL.					
		iP_Z	*3 57 40*					
		i_Z	*3 59 27*					
		S_Z	*4 03 25*					
		eL_Z	*4 07 24*	*17*				
		L_Z	*4 19 ..*	*17*				
		F	*4 44 ..*					
19	....	L_E	23 16 23	18				Very heavy microseisms; N.-S. component does not show.
		F_E	23 23 ..					
22	....	eL_E	4 16 ..					N.-S. component barely shows.
		L_E	4 18 ..	23				
		L_E	4 27 ..	20				
		F	4 30 ..					
22	....	L_E	21 38 20					Heavy microseisms; E.-W. comp. does not show.
		F	22 10(*ca*)					
26	....	e_E	9 37 27					Heavy microseisms
		e_N	9 37 27					
		eL_E	9 42 00	13				
		eL_N	9 41 36	13				
		L_E	9 51 25	15				
		L_N	9 51 ..	15				
		F	10 15 ..					
31	....	iP_E	13 24 36					Time evaluation very difficult because of severity of quake.
		iP_N	13 24 36					
		iS_E	13 30 28					
		iS_N	13 30 28					
		eL_E	13 36 00	11				
		eL_N	13 36 00	11				
		M_{E1}	13 38 18			*24,500		
		M_{N1}	13 38 35		*24,300			
		M_{E2}	13 43 02			*19,000		
		M_{N2}	13 39 42		*18,700			
		M_{E3}	13 44 10			*20,500		
		M_{N3}	13 41 42		*15,600			
		M_{N4}	13 43 16		*15,500			
		F	17 (*ca*)					
			VERTICAL.					
		iP_Z	*13 24 35*					
		eS_Z	*13 30 38*					
		eL_Z	*13 34 24*	14				
		M_Z	*13 40 39*					

* Trace amplitude.

TABLE 2—*Instrumental seismological reports, January, 1922*—Continued.

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

1922.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	eL	20 39 ..	22				
	L	20 50 ..	16				
	F	21 05 *ca.*					
6	P	14 20 35				6,200	
	S	14 28 24					
	eL	14 37 45	30				
	L	14 44 30	18				
	F	15 20 ..					
9	P	5 15 50				3,400	
	S	5 21 00					
	L	5 24 27	20				
	F	6					
17	P	3 57 39				4,000	
	S	4 03 26					
	L	4 07 48					
	M_E	3 40 ..		*45,000			
	F	5 40 *ca.*					
20	e	4 45 00					
	F	4 51 ..					
22	eL	4 17 30	24				
	L	4 27 ..	16				
	F	4 40 *ca.*					
22	eL	21 38 ..					
	F	21 47 ..					
26	e	9 38 15					
	L	9 50 45	16				
	F	10 20 ..					Micros.
31	iP	13 24 35				4,000	
	iS	13 30 23					
	L	13 34 45					
	M_E	13 44 ..		*45,000			
	F	16 20 *ca.*					

ILLINOIS. *U. S. Weather Bureau, Chicago.*

1922.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	P	20 11 07				6,500	
	PR1	20 13 24					
	S	20 19 05					
	eL	20 31 30					
	L	20 38 ..	22				
	L	20 42 ..	18				
	F	21 40 *ca.*					
6	P	14 21 08				6,500	L lost in changing sheets.
	S	14 29 12					
	F	16 40 *ca*					
6	eL	19 52 30					
	L	19 57 ..	16				
	F	20 30 *ca.*					
8	eL	2 32 30	18				
	F	3 *ca.* ..					
9	P	5 17 00				4,200	
	S	5 23 00					
	L	5 27 44	30				
	L	5 41 ..	15				
	F	7 20 *ca.*					
17	P	3 58 22					S and L indistinguishable owing to faintness of record.
	F	7 50 *ca.*					
19	L	23 00 10					
	L	23 03 20	22				
20	F	0 30 ..					Lost in micros.
20	eL	4 42 ..	16				
	F	5 *ca.* ..					
22	S?	3 56 15					
	L	4 11 ..	22				
	L	4 18 ..	16				
	F	6 20 *ca.*					Do.
22	e	21 11 30					
	L	21 32 00	25				
	L	21 40 ..	16				
	F	23 *ca.* ..					
26	e	9 30 10					
	S?	9 34 30					
	L	9 45 45					
	F	10 30 *ca.*					Do.
31	P	13 23 15				3100	L lost through faintness of record.
	S	13 28 07					
	F	17 30 *ca.*					

*Trace amplitude.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

1922.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 6	eP_N	14 20 56			2		
	S_E	14 28 39					
	S_N	14 28 19					
	L_E	14 36 34	34				
	L_N	14 38 36	15				
	M_E	14 45 19	18	20			
	M_N	14 46 41	18		10		
	F_E	15 06 ..					
	F_N	15 15 ..					
9	P_E	5 15 45	3				
	P_N	5 15 52	3				
	S_E	5 20 48	13				
	L_E	5 23 46					
	L_N	5 22 19	28				
	M_E	5 24 38	18	10			
	M_N	5 23 14	20		20		
	C_E	5 32 ..					
	C_N	5 24 ..					
	F_E	5 47 ..					
	F_N	5 56 ..					
17	eP_E	3 57 55					Recorded on magnetograph (D) from 4:03 to 4:21. Actual maximum at 4:03:46 on E (960) and 4:03:44 on N (340).
	iP_N	3 57 43	3				
	L	4 03 31	12				
	L_E	4 06 43	20				
	M_E	4 07 07	20	380			
	M_N	4 07 07	15		150		
	C_E	4 07 38					
	C_N	4 07 56					
	F_E	4 44 ..					
	F_N	4 42 ..					
22	e_E	4 17 16	17				
	e_N	4 17 59					
	e_N	4 20 28	9				
	L_N	4 23 45	20		10		
	M_E	4 20 52	15	20			
	C_E	4 25 ..	16				
	F_E	4 41 ..					
	F_N	4 30 ..					
26	e_N	9 41 39					Preliminary phases hidden by microseisms.
	eL	9 51 02	20				
	M_E	9 54 20	13	30			
	M_N	9 51 58	14		20		
	C_E	9 54 38					
	C_N	9 54 43	9				
	F_E	10 03 ..					
	F_N	10 00 ..					
31	iP_E	13 24 32	6				*N stylus off sheet from 13:38:30 to 13:39:00.
	eP_N	13 24 37	2				
	iS	13 30 20	10				
	L_E	13 36 41	32				
	L_N	13 34 41	35				
	L_N	13 35 50	35				
	M_E	13 41 14	14	1,600			
	M_N	*	14		4,100+		
	C_E	13 44 ..	14				
	C_N	13 44 ..	15				
	F_E	15 25 ..	10				
	F_N	15 12 ..	11				

MISSOURI. *St. Louis University, St. Louis.*

1922.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 9	iP	5 17 18				3,500?	
	S	5 23 30?					
	L	5 26 12					
	M	5 27 42	30		*18,000		
	F	5 45 ..					
17	iP	3 58 03				2,100	
	S	4 00 00					
	L	4 01 18					
	M_E	4 04 06	6	*52,000			
	M_N	4 04 12	6		*37,000		
	F	4 46 ..					
31	iP	13 23 12				3,000	
	S	13 27 54					
	L	13 29 42					
	M_E	13 35 30	12	*56,000			
	M_N	13 35 30	12		*68,000		Continuing for 3 min.
	F	15 22 ..					

*Trace amplitude.

TABLE 2.—*Instrumental seismological reports, January, 1922*—Continued.

NEW YORK. *Cornell University, Ithaca.*

1922.		H. m. s.	Sec.	μ	μ	Km.	
Jan. 1	eL	20 39 30					
	L	20 41 ..	20				
	L	20 46 ..	18				
	F	21 08 ..					
5	eL	9 29 ..	12				Obscured by micros.
	F	9 35 ..					
6	eP_N	14 21 04	4				S about 14:29:18, obscured by local disturbance.
	L	14 38 18	40				
	L	14 45 ..	20				
	L	14 56 ..	16				
	F	15 13 ..					
9	P	5 15 58	3				
	PR1	5 15 55	4				
	S	5 21 19	5				
	L_N	5 22 50	35				
	L_E	5 23 20	24				
	F	6 18 ..					
17	P	3 58 10	2				
	S	4 04 13					
	M_E	4 04 25	5	*8,500			
	i_E	4 07 00	6	*6,500			
	L_N	4 08 ..	32				
	F	5 18 ..					
20	eL	4 45 ..	10				May not be seismic.
	F	4 55 ..					
22	L	4 18 30	22				
	F	4 38 ..					
26	L	9 50 47	21				
	F	10 05 ..					
31	P_E	13 24 31	5				
	S_N	13 30 13	9				
	eL	13 33 30	60				
	F	16 18 ..					

*Trace amplitude.

NEW YORK. *Fordham University, New York.*

1922.		H. m. s.	Sec.	μ	μ	Km.	
Jan. 6	e_E	14 28 04					
	L_E	14 50 ..					
9	eP?$_E$	5 15 37					
	M_E	5 22 *ca*					
21	L	16 24 ..					Long waves of small amplitude.
31	P_N	13 24 56				4,300	Clock marks obscured.
	P_E	13 24 50					
	S_N	13 30 47					
	S_E	13 30 44					
	L_N	13 37 *ca*					
	L_E	13 37 *ca*					
	M	13 41 *ca*		*23,360			

*Trace amplitude.

CANAL ZONE. *Panama Canal, Balboa Heights.*

1922.		H. m. s.	Sec.	μ	μ	Km.	
Jan. 1	P_E	11 55 52				320*ca.*	Probably SW.
	S_E	11 56 58					
	S_N	11 56 26					
	L_E	11 56 58					
	L_N	11 56 54					
	M_E	11 57 00		*400			
	M_N	11 57 00			*800		
	F_E	12 00 00					
	F_N	12 00 30					
2	P	6 24 02				70*ca.*	Probably SW.
	S	6 24 10					
	M_E	6 24 12		*4000			
	M_N	6 24 16			*13000		
	F_E	6 25 20					
	F_N	6 25 15					
6	P_N	14 16 46				3100*ca.*	Probably NW. Time of phases on EW not clearly marked.
	S_N	14 21 36					
	L_N	14 25 12					
	M_N	14 28 00		*600	*1200		
	F_N	15 17 20					
8	P_E	13 45 12				265*ca.*	Probably SW. NS pen off sheet, no record.
	S_E	13 45 41					
	L_E	13 45 56					
	M_E	13 45 54		*2000			
	F_E	13 48 15					
9							Very slight tremors between 5:17 and 5:35, and 22:09:25 and 22:14:0. Probably local shock; direction and distance unknown.
10							Very slight tremor between 23:04 and 23:06, probably local, distance and direction unknown.
17	P_E	3 53 42				720*ca.*	Probably SW.
	P_N	3 53 44					
	S_E	3 54 52					
	S_N	3 54 56					
	L_E	3 56 06					
	L_N	3 56 08					
	M_E	3 56 38		*73000			Damper thrown off on NS.
	F_E	4 31 00					
31							Slight tremor from distant disturbance between 13:30 and 14:30; newspaper reports quake off coast of Oregon.

*Trace amplitude.

TABLE 2.—*Instrumental seismological reports, January, 1922*—Continued.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 3		eP_E	1 12 42	4				Local shock. Recorded by magnetocgraph, 1:11 to 1:12:30.
		L_E	1 13 04	14				
		L_N	1 12 48	10				
		M_E	1 13 20	12	80			
		M_N	1 13 18	9		30		
		F_E	1 27 ..					
		F_N	1 19 ..					
6		eL_E	14 35 13					
		eL_N	14 34 42	16				
		M_E	14 37 46	15	50			
		M_N	14 37 50	16		50		
		e_E	14 42 10	18				
		F_E	14 56 ..					
		F_N	14 49 ..					
9		iP	5 14 10	4				L not clear. Recorded by magnetograph, 5:15 to 5:18.
		S_N	5 17 51					
		eL_E	5 18 38					
		L_N	5 19 13					
		M_E	5 18 45	14	220			
		M_N	5 19 33	6		140		
		C	5 23 ..	6				
		F_E	6 23 ..					
		F_N	5 55 ..					
17		P	3 55 08	3				Recorded by magnetograph; P, 3:55; L, 3:58; F, 4:11.
		L	3 57 45	19				
		e_E	3 58 39	15				
		M_E	3 58 52	16	1,280			
		M_N	3 59 00	18		670		
		C	4 05 ..	15				
		F_E	4 37 ..					
		F_N	4 32 ..					
31		P	13 27 13	7				
		S_E	13 35 03					
		S_N	13 35 16					
		L_E	13 46 29	20				
		L_N	13 44 55	40				
		M_E	13 47 51	18	60			
		M_N	13 51 20	21		200		
		C_E	13 50 33	13				
		C_N	13 53 23					
		F_E	14 26 ..					
		F_N	14 23 ..					

VERMONT. *U. S. Weather Bureau, Northfield.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 1		eL	20 45 ..	18				
		F	21 *ca* ..					
6		eL	14 46 ..					
		F	14 58 ..					
9		e	5 16 15					
		L	5 23 40	20				
		F	5 40 ..					
17		P	3 58 22				4,400	L indistinguishable.
		S	4 04 32					
		F	5 *ca*...					
26		e	9 44 ..					
		L	9 52 ..	16				
		F	10 15 ..					
31		P	13 24 47				4,300	
		S	13 30 50					
		L	13 35 50	24				
		M_E	13 43 ..		*35,000			
		F	16 10 ..					

* Trace amplitude.

CANADA. *Dominion Observatory, Ottawa.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 6		P						Lost in micros.
		S_E	14 29 41					
		eL_E	14 36 ..					
		L_E	14 39 ..	40				
		L_E	14 44 ..	20				
		L_E	14 52 ..	15				
		F	15 45 ..					
9		O	5 09 32				3,440	
		P	5 16 08					
		S_E	5 21 21					
		eL_E	5 23 30					
		L_E	5 26 ..	19				
		L_E	5 29 ..	15				
		L_E	5 40 ..	11				
		F	6 40 ..					
17		O	3 50 17				4,780	EW component not working.
		P_N	3 58 30					
		$PR2_N$?	4 00 32					
		S_N	4 05 00					
		eL_N	(4 11 40)					
		F	5 00 *ca.*					
		SASKATOON RECORD.						
		O	3 50 22				6,160	Sharp, well-defined record, yielding very good value for distance.
		iP	4 00 02					
		$PR1_N$	4 02 30					
		iS	4 07 47					
		L?	4 16 30					
		F	4 50 ..					
19		eL_E	23 03 ..	27				
		L_E	23 17 30	15				
		F	23 32 *ca.*					
22		eS_E?	3 52 22					
		$eSR1_E$?	3 58 30					
		eL_E	4 15 ..	26				
		L	4 21 ..	19				
		L	4 26 ..	17				
		L_E	4 33 ..	15				
		L_E	4 37 ..	17				
		L_E	4 44 ..	15				
		L_E	4 52 ..	15				
		F	5 10					
22		e_E	21 12 56					Sinusoidal L waves of small amplitude well defined. Preliminary phases only faintly shown.
		e_E	21 19 15					
		L_E	21 36 ..	26				
		L_E	21 42 30	19				
		L_E	21 48 ..	15				
		L_E	21 59 ..	15				
		L_E	22 05 ..	19				
		L_E	22 09 ..	19				
		L_E	22 14 ..	15				
		F	22 30 ..					
26		e	9 38 30					
		eS_E?	9 41 22					
		eL	9 49 30					
		L	9 51 ..	15				
		L_E	9 53 30					
		F	10 17 ..					
31		O	13 17 19				3,900	
		iP	13 24 30					
		iS	13 30 11					
		eL	13 34 ..					
		M_N	13 37 54					
		M_E	13 40 07					
		F	17 05 ..					
		SASKATOON RECORD.						
		O	13 17 06				2,000	
		iP	13 21 18					
		iS_E	13 24 40					
		M	13 28 26					
		F	14 58 ..					
		HALIFAX RECORD.						
		O	13 17 19				4,900	
		P_E	13 25 43					
		S_E	13 32 22					
		$SR1_E$	13 35 47					
		eL	13 38 47					
		M_N	13 41 07					
		F	15 *ca.*..					

TABLE 2.—*Instrumental seismological reports, January, 1922*—Continued.

CANADA. *Dominion Meteorolgical Service, Toronto.*

			H. m. s.	Sec.	μ	μ	Km.	
Jan. 1		e?	20 16 30?					
		e	20 20 24?					Early phases masked by micros.
		eL	20 43 06					
		M	20 51 42			*1,300		
		F	Micros.					
		L	9 27 24			*50		Thickening.
1		F	9 31 36					
6		P	Micros.					
		S	14 30 30					
		eL	14 38 06					
		eL	14 42 12					
		eL	14 45 54			*1,300		
		M	14 48 54					
		eL	14 55 18					
		eL	15 30 12					
		F	Micros.					
9		iP	5 16 24					
		iS	5 21 30					All phases well defined.
		eL	5 26 12					
		iL	5 29 12					
		M	5 31 12			*2,000	3,330	
		eL	5 35 30					
		eL	5 57 12					
		F	6 43 30					
17		?PR	4 00 00					May be a dual earthquake.
		i	4 04 06					
		M	4 04 36			*13,000		Characteristics very abnormal. S waves should come in when Max. movement took place.
		iL	4 10 12?					
		eL	4 14 24					
		eL	4 44 12					
		eL	5 00 00					
		eL	5 44 12					
		F	6 10 42					
19		L	23 03 30					
		eL	23 12 18					
		M	23 24 00			*300		
19		eL	0 06 12					A dual eq.
		M	0 12 30			*500		
		F	Micros.					
22		eL	4 15 24					P & S masked by micros.
		eL	4 19 12					
		M	4 27 54			*1,300		
		F	5 14 18					
22		E or L.	21 18 48					Micros masked preliminary phases.
		eL	21 38 48					
		M	21 47 54			*1,300		
		F	Small micros.					
26		S?	9 41 18					
		eL	9 50 12					
		iL	9 52 48					
		M	9 53 12			*300		
		F	10 20 48					
31		iP	13 24 30					
		e	13 29 42					
		iS	13 30 12					
		iL?	13 35 30					Well defined seismogram.
		iL?	13 37 30					
		M	13 39 54			*16,000	3,910	
		eL	14 15 42					
		eL	15 15 30					
		eL	15 24 48					
		eL?	15 52 48?					
		F	Micros.					

*Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

			H. m. s.	Sec.	μ	μ	Km.	
Jan. 1		P	20 02 19					
		L	20 15 35					
		M	20 27 53			*1,500		
		F	21 52 57					
5		L	9 09 12					
		M	9 11 11			*400		
		F	9 21 36					
6		P	14 24 02					
		S	14 33 23?					
		L	14 43 42					
		M	14 56 59			*4,000		
		F	17 05 51					
6		L	20 02 28					
		M	20 06 58			*300		
		F	20 12 28					
6		M	20 24 28			*250		
		F	20 28 58					
9		iS	5 27 54					Initial S movement sharply to the West, and S. & L. waves beautifully defined.
		L	5 38 22					
		M	5 45 18			*2,250		
		F	7 53 02					
17		iP?	4 00 39					
		eS?	4 02 08					
		L?	4 07 05					P may be PR.
		i	4 08 57					Abnormal seismogram.
		M	4 09 35			*4,500	?660	
		eL	5 02 21					
		eL	5 50 00					
		F	6 53 12					
19		P	22 24 50					
		L	22 43 31					
		M	22 55 49			*500		
		F	0 39 35					
20		L	4 41 26					
		M	4 44 24			*400		
		F	4 56 16					
22		P	3 46 07					
		S	3 50 03?					
		L	3 57 55					
		M	4 06 56			*1,500	2,390?	
		F	5 15 08					
22		P	21 07 38					
		L	21 21 04					
		M	21 26 44			*700		
		F	22 26 14					
26		P	9 20 45					Probably off the north coast of California.
		L	9 22 33					
		M	9 23 05			*500	800	
		F	9 31 04					
26		P	9 32 33					Probably north of former quake.
		L	9 34 01					
		M	9 34 41			*2,500	660	
		F	9 51 23					
31[1]								
			VERTICAL SEISMOGRAM.					
6		P	14 23 30	2.5				
		M	14 58 00	20		6		
17		P	4 00 40	2.5				
		S	4 02 45	4				
		L	4 08 50	5				
		M	4 09 05	5		30	925	
26		P	9 21 00	2				
		L.&M.	9 23 00	12		2	840	Probably off north coast of California.
26		P	9 32 30	2				
		L.&M.	9 34 30	15		6	840	Do.
31		P	13 18 00	3				
		L	13 20 00	7				
		M	12 22 55	7		119	880	Off north coast of California.

* Trace amplitude.

[1] Record lost; clock stopped.

No earthquakes were recorded at the following stations during January, 1922:

CALIFORNIA. *Theosophical University*, Point Loma.

No reports for January, 1922, have been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
HAWAII. *U. S. C. & G. S. Magnetic Observatory*, Honolulu.
MASSACHUSETTS. *Harvard University*, Cambridge.

TABLE 3.—*Late reports (instrumental).*

CALIFORNIA. *Theosophical University, Point Loma.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 3	....	....	....	....	50	50	....	Tremors.
6	....	....	....	....	100	100	....	Do.
8	....	....	19 54 00	....	600	550	....	Light shock.
10	....	....	....	....	200	200	....	Tremors.
11	....	....	....	....	250	250	....	
13	....	....	....	....	200	200	....	
14	....	....	....	....	50	100	....	
17	....	....	....	....	100	100	....	
Oct. —	....	....	....	....	....	....	....	No records kept.
Nov. —	....	....	....	....	....	....	....	Do.
Dec. —	....	....	....	....	....	....	....	Do.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1921			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 5	....	e_N....	1 57 45	20	....	....	....	Very slight.
		F_N....	2 01 25	....	....	....	....	
10	....	iP....	2 25 45	11	*2,500	*3,000	....	Maximum amplitude occurs at iP; no definite M during L.
		S_N....	2 33 02	....	....	....	....	
		SRl_N..	2 37 07	....	....	....	....	
		L....	2 41 30	19	....	....	....	
		C....	2 48 ..	....	....	....	....	
		F_E....	2 55 ..	....	....	....	....	
		F_N....	2 53 ..	....	....	....	....	
15	....	e....	5 07 11	....	....	....	....	e may not be seismic; S may be an L phase.
		P....	5 14 11	16	....	....	....	
		S_E....	5 18 25	18	....	....	....	
		S_N....	5 18 50	18	....	....	....	
		L_E....	5 21 05	26	....	....	....	
		L_N....	5 20 50	25	....	....	....	
		M_E....	5 26 35	20	*5,200	....	....	
		M_N....	5 25 10	20	....	*5,000	....	
		C_E....	5 37 ..	16	....	....	....	
		C_N....	5 36 ..	15	....	....	....	
		F_E....	6 05 ..	....	....	....	....	
		F_N....	6 03 ..	....	....	....	....	
18	....	e....	0 53 ..	20	....	....	....	Very slight.
		F_E....	0 58 ..	....	....	....	....	
		F_N....	0 56 ..	....	....	....	....	
Nov. 2	....	e_E....	8 37 ..	20	....	....	....	Almost hidden by micros.
		e_N....	8 33 ..	....	....	....	....	
		F_E....	9 08 ..	....	....	....	....	
		F_N....	9 23 ..	....	....	....	....	
6	....	e....	17 13 50	....	....	....	....	Very faint record; beginning lost in changing paper, from 17*h* 06*m* 50*s* to 17*h* 13*m* 50*s*.
		F....	17 42 ..	....	....	....	....	

* Trace amplitude.

TABLE 3.—*Late reports (instrumental)*—Continued.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Con.

1921			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 7	....	P_E....	16 11 32	7	....	....	....	
		S_E....	16 20 43	9	....	....	....	
		S_N....	16 20 48	....	....	....	....	
		L_E....	16 34 16	24	....	....	....	
		M_E....	16 34 30	....	*3,000	....	....	
		C_E....	16 48 34	20	....	....	....	
11	....	e....	14 45 44	12	....	....	....	Phases indistinct.
		e_N....	14 48 02	....	....	....	....	
		L....	14 48 51	23?	....	....	....	
		M_E....	14 49 00	....	*2,000	....	....	
		M_N....	14 49 45	....	....	*2,100	....	
		C_E....	14 51 ..	....	....	....	....	
		C_N....	14 53 ..	....	....	....	....	
		F_E....	14 58 ..	....	....	....	....	
		F_N....	15 07 ..	....	....	....	....	
11	....	P_E....	18 47 55	....	....	....	....	Actual maximum amplitude occurs during S: 9.0 mm. at 18*h* 58*m* 20*s* on E and 7.0 mm. at 18*h* 57*m* 30*s* on N.
		P_N....	18 47 37	....	....	....	....	
		S....	18 57 22	20	....	....	....	
		L_E....	19 10 08	33	....	....	....	
		M_E....	19 22 ..	22	*8,000	....	....	
		M_N....	19 19 20	20	....	*3,200	....	
		C_E....	19 45 ..	15	....	....	....	
		C_N....	19 55 ..	15	....	....	....	
		F_E....	20 27 ..	....	....	....	....	
		F_N....	20 46 ..	....	....	....	....	
13	....	e_E....	14 07 55	....	....	....	....	Very slight.
		L_N....	14 12 05	22	....	*500	....	
		F_E....	14 18 ..	....	....	....	....	
		F_N....	14 21 ..	....	....	....	....	
14	....	P_E....	7 08 12	....	....	....	....	
		P_N....	7 08 00	....	....	....	....	
		S....	7 11 50	....	....	....	....	
		L_E....	7 13 58	20	....	....	....	
		L_N....	7 14 11	22	....	....	....	
		M_E....	7 16 30	20	*1,500	....	....	
		M_N....	7 16 55	15	....	*2,000	....	
		C_E....	7 21 ..	....	....	....	....	
		C_N....	7 19 ..	....	....	....	....	
		F_E....	7 32 ..	....	....	....	....	
		F_N....	7 35 ..	....	....	....	....	
15	....	P_N....	20 54 47	8	....	....	....	Actual maximum occurs during S, 3.0 mm. at 21*h* 12*m*. E record hidden by overlapping traces.
		S_N....	21 04 51	14	....	....	....	
		L_N....	21 21 05	35	....	....	....	
		M_N....	21 22 ..	30	....	*1,200	....	
		F_N....	22 11 ..	15	....	....	....	
29	....	e_E....	21 03 52	....	....	....	....	
		e_N....	21 05 25	....	....	....	....	
		M_E....	21 05 45	14	*1,500	....	....	
		M_N....	21 13 35	15	....	*1,500	....	
		F_E....	21 14 ..	....	....	....	....	
		F_N....	21 20 ..	....	....	....	....	

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1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*
Nov. 2	....	L....	8 31 30	20	....	....	....
		F....	8 35 ..	....	....	....	....
11	....	eP_E...	18 56 48	4	....	....	....
		e_E....	19 08 ..	6	....	....	....
		e_N....	19 13 ..	6	....	....	....
		eL_E...	19 30 ..	20	....	....	....
		L....	19 45 ..	24	....	....	....
		e....	19 56 18	5	....	....	....
		F....	20 47 ..	....	....	....	....
15	....	eP....	20 49 30	4	....	....	....
		PRl...	20 53 34	5	....	....	....
		e_N....	20 55 30	4	....	....	....
		iS....	20 59 53	6	....	....	....
		eL....	21 24 ..	20	....	....	....
		F....	21 47 ..	....	....	....	....
Dec. 18	....	P....	15 37 20	4	....	....	....
		S_E....	15 43 18	....	....	....	....
		M_E....	15 43 33	7	*4,400	....	....
		M_E....	15 46 13	7	*3,700	....	....
		F....	16 13 ..	....	....	....	....

* Trace amplitude.

Chart I. Hydrographs of Several Principal Rivers, January, 1922.

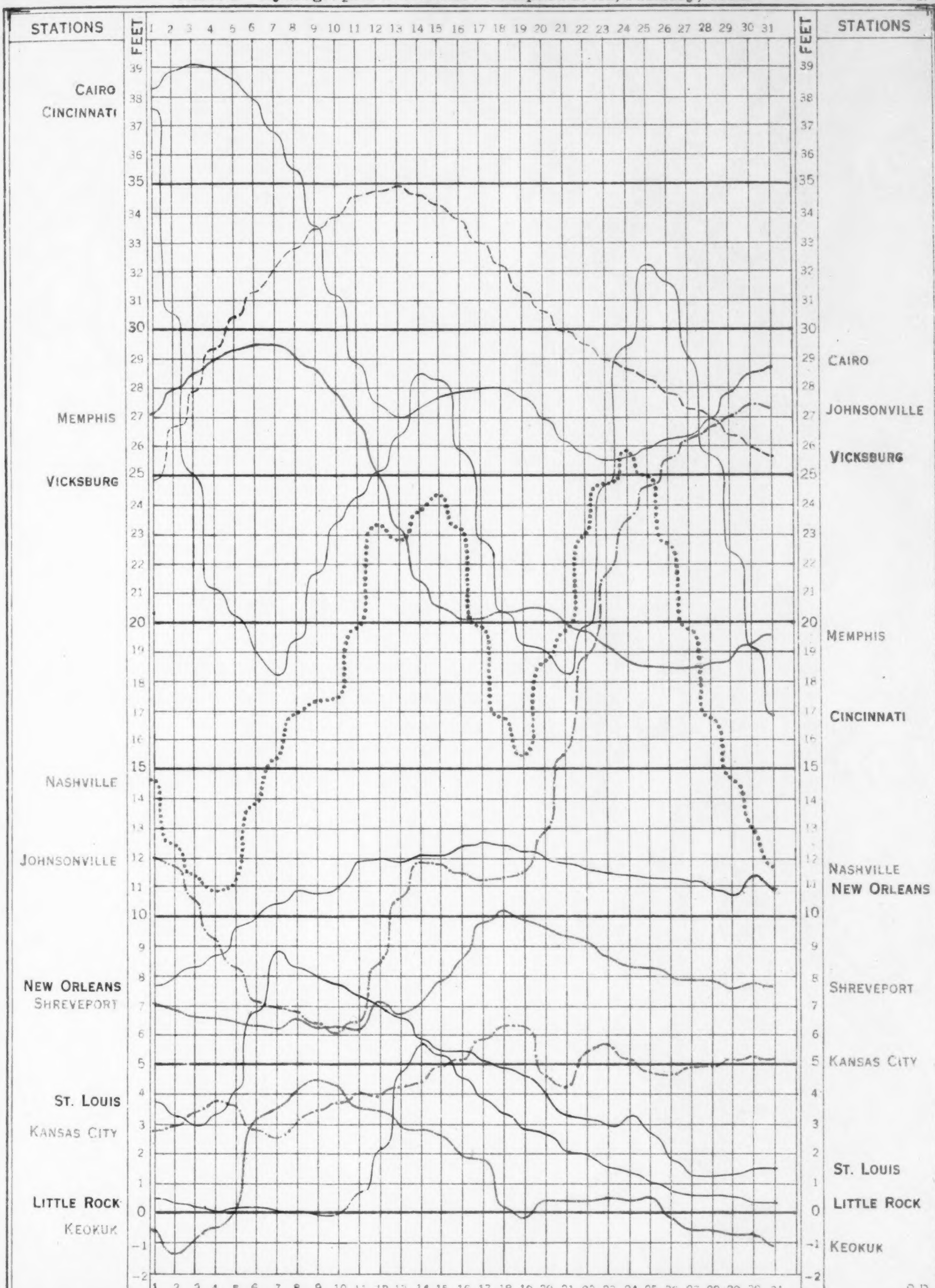


Chart II. Tracks of Centers of Anticyclones, January, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.

(Plotted by Wilfred P. Day.)

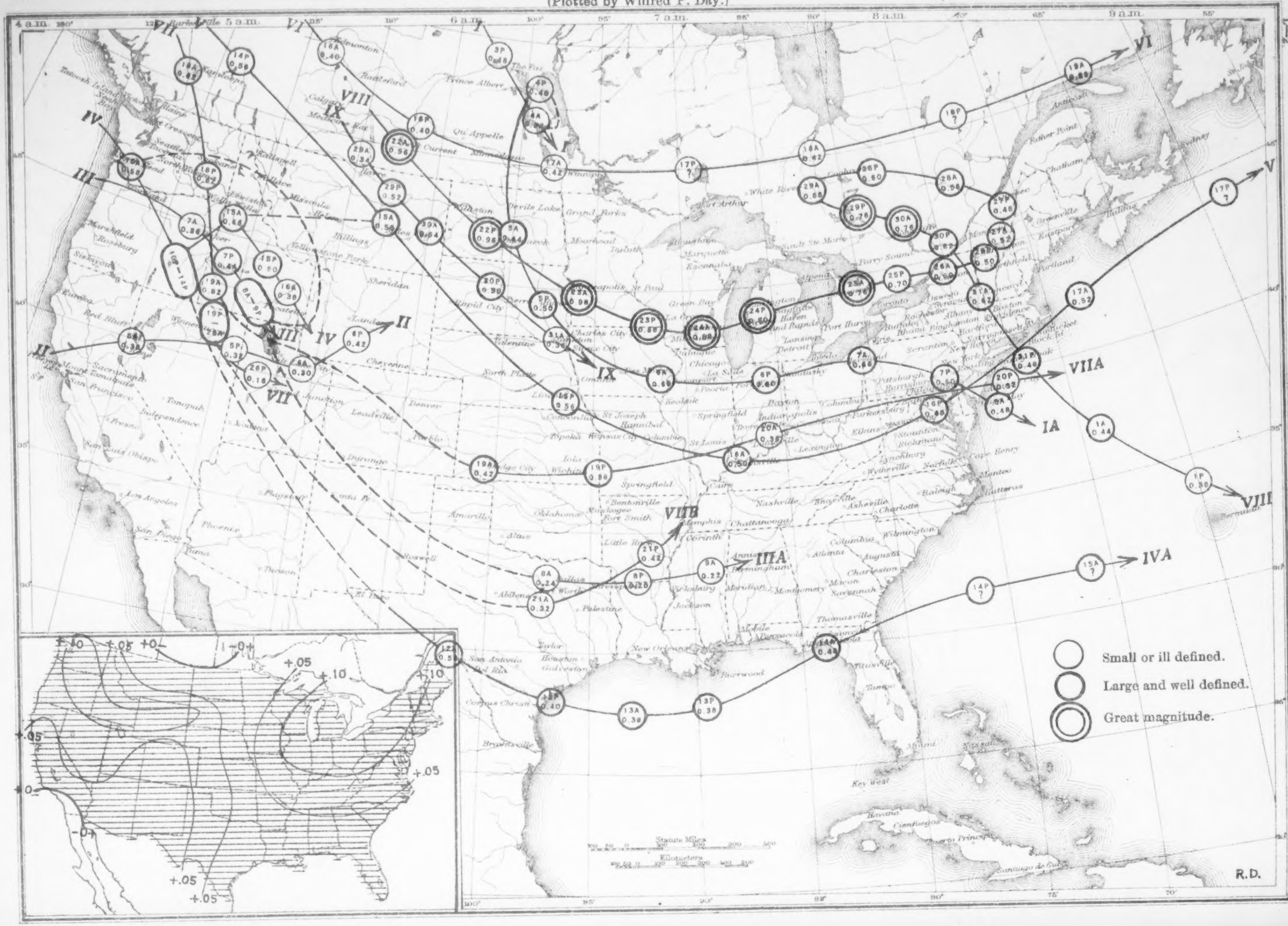


Chart III. Tracks of Centers of Cyclones, January, 1922. (Inset) Change in Mean Pressure from Preceding Month.

Chart III. Tracks of Centers of Cyclones, January, 1922. (Inset) Change in Mean Pressure from Preceding Month.
(Plotted by Wilfred P. Day.)

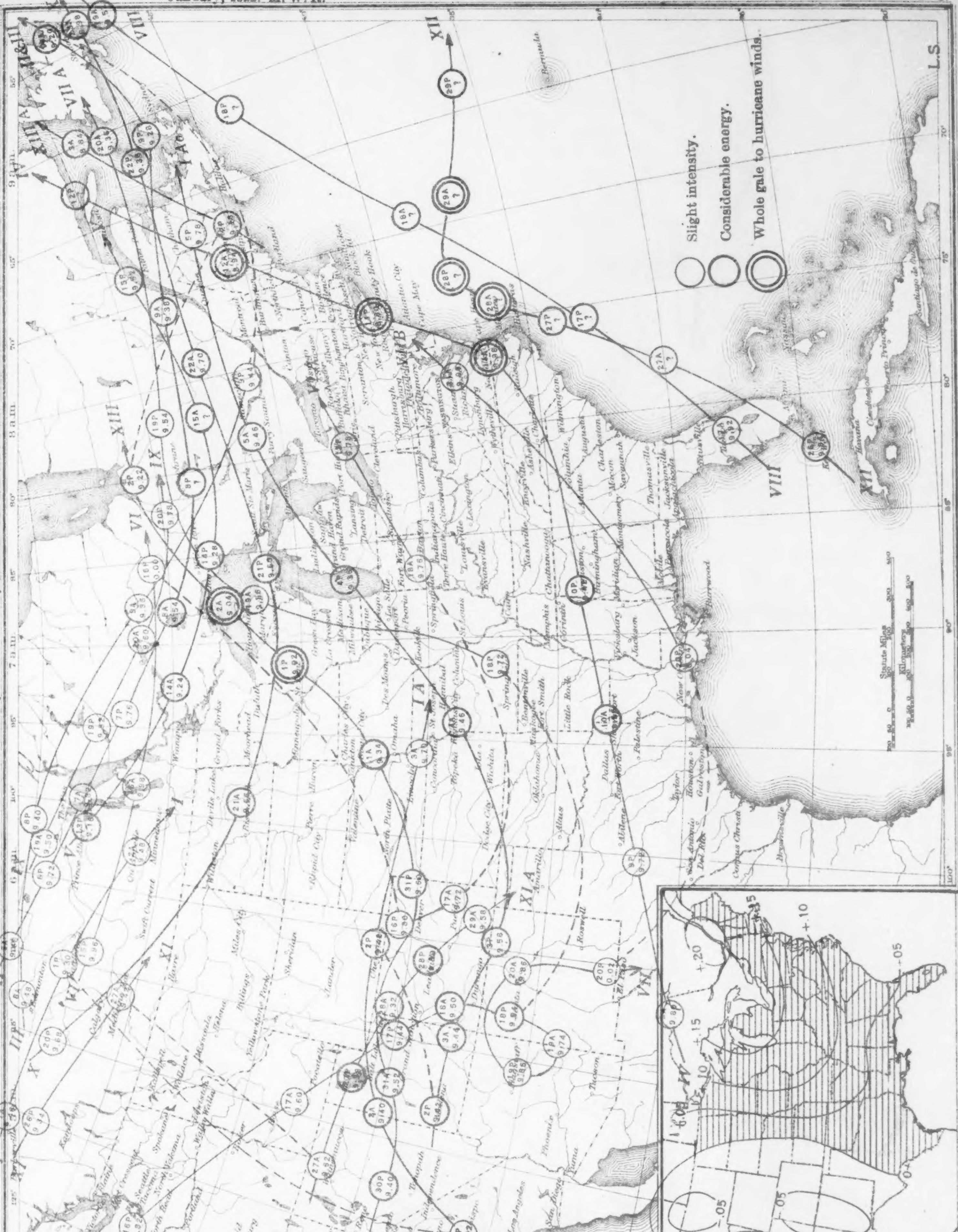


Chart IV. Departure (°F.) of the Mean Temperature from the Normal, January, 1922.

Chart V. Total Precipitation, Inches, January, 1922. (Inset) Departure of Precipitation from Normal.

Chart V. Total Precipitation, Inches, January, 1922. (Inset) Departure of Precipitation from Normal.

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, January, 1922.

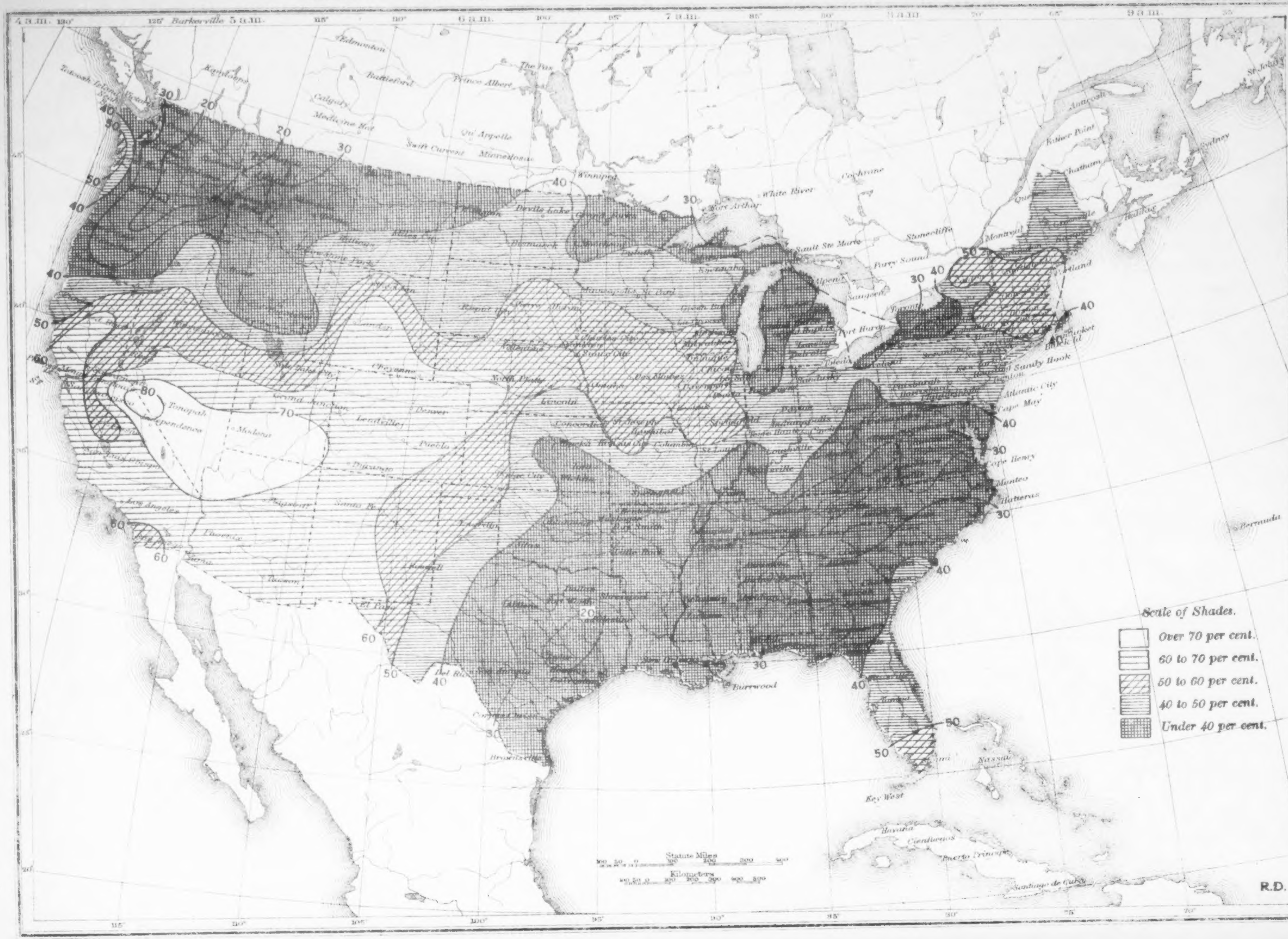


Chart VII. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, January, 1922.

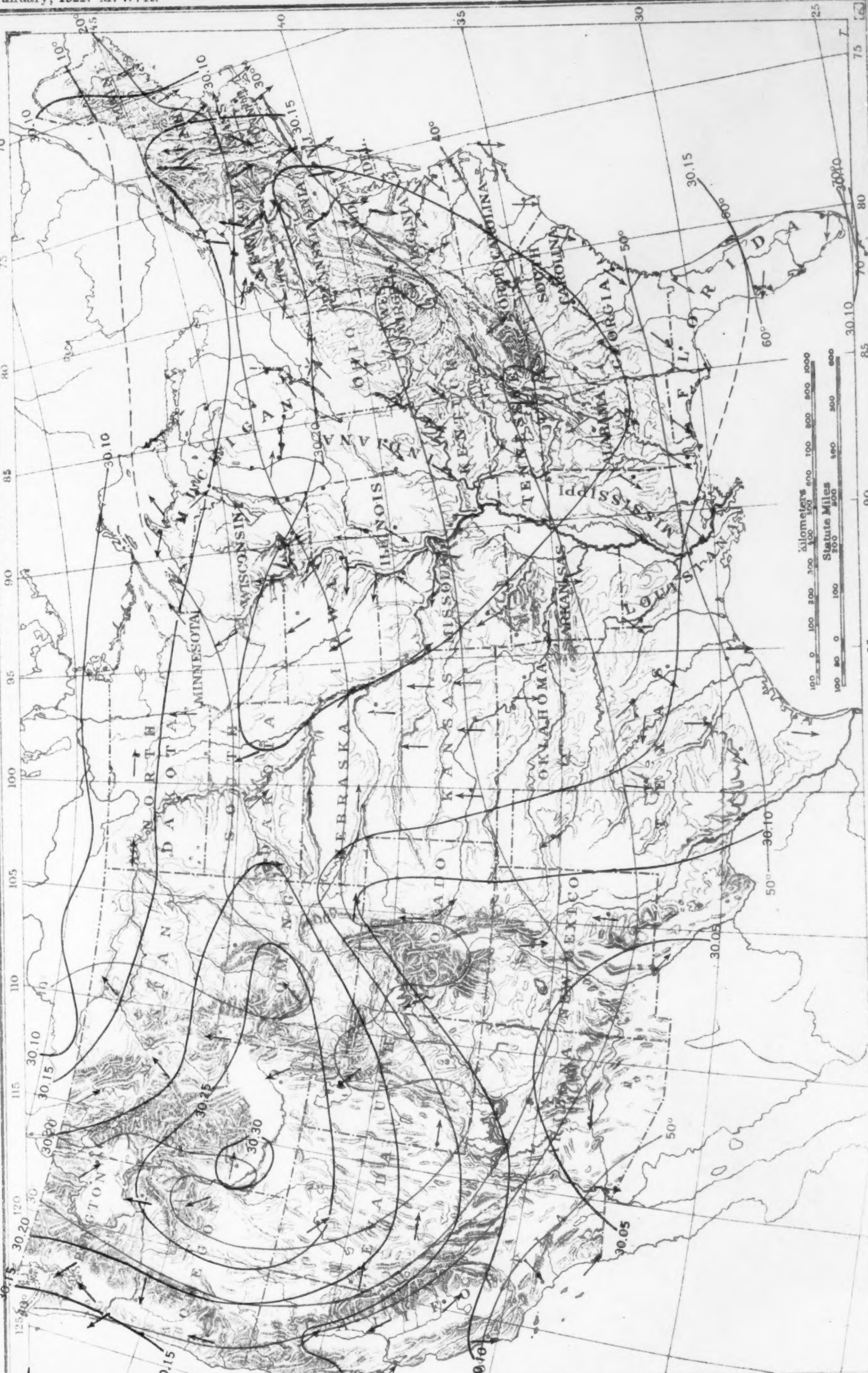


Chart VIII. Total Snowfall, Inches, January, 1922. (Inset) Depth of Snow on Ground at end of Month.

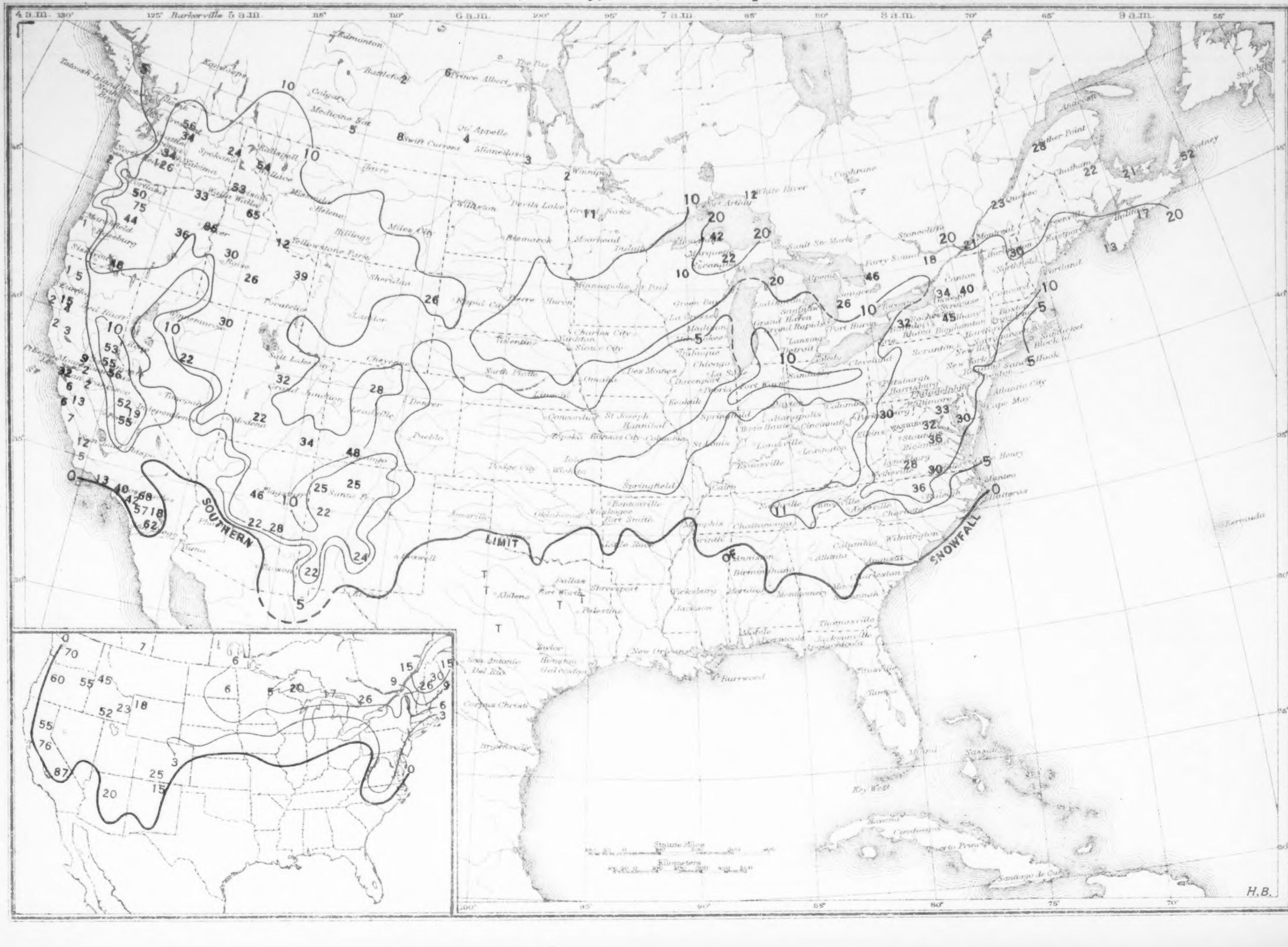
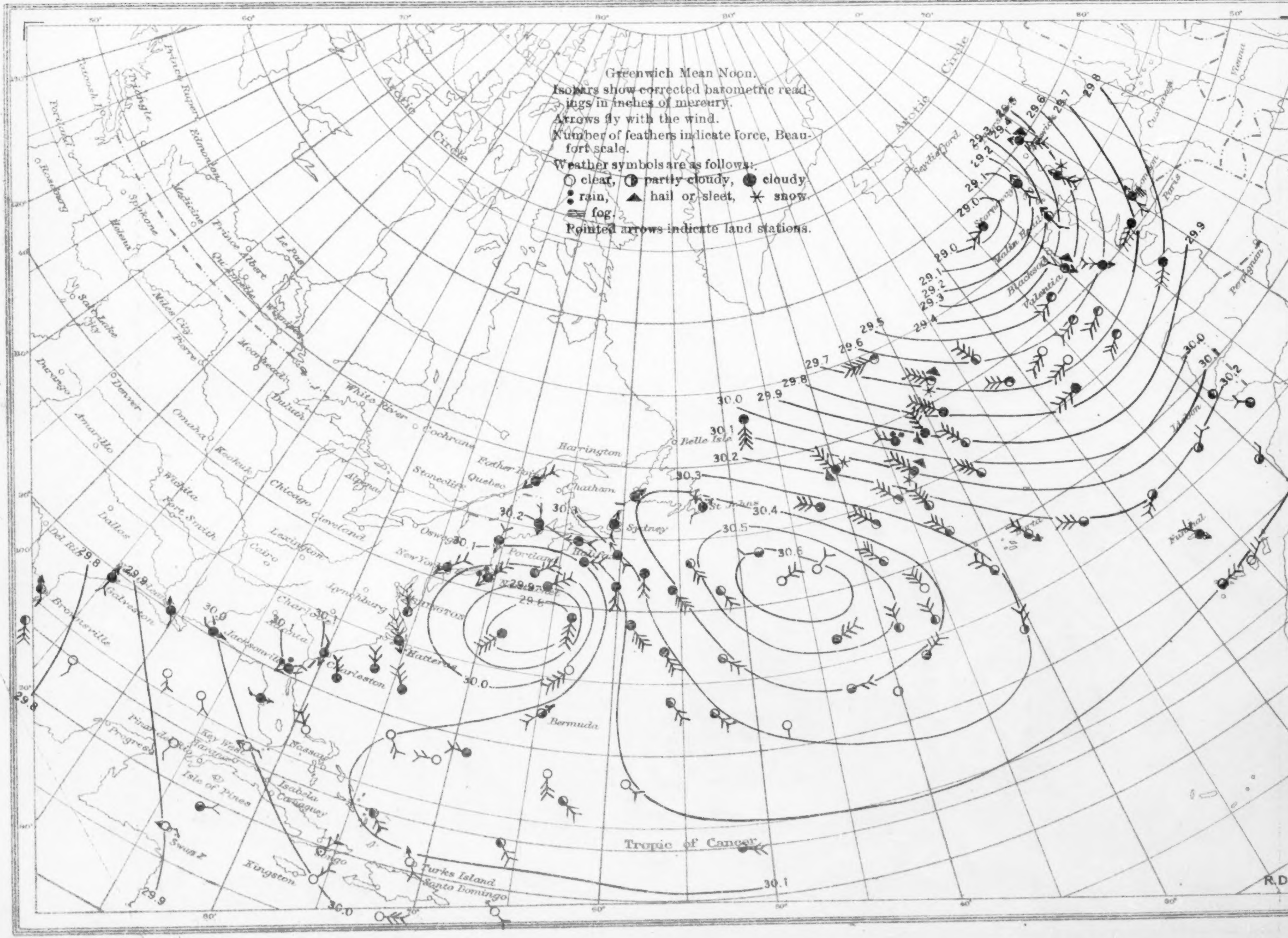


Chart IX. Weather Map of North Atlantic Ocean, January 18, 1922.

Chart IX. Weather Map of North Atlantic Ocean, January 18, 1922.

(Plotted by F. A. Young.)



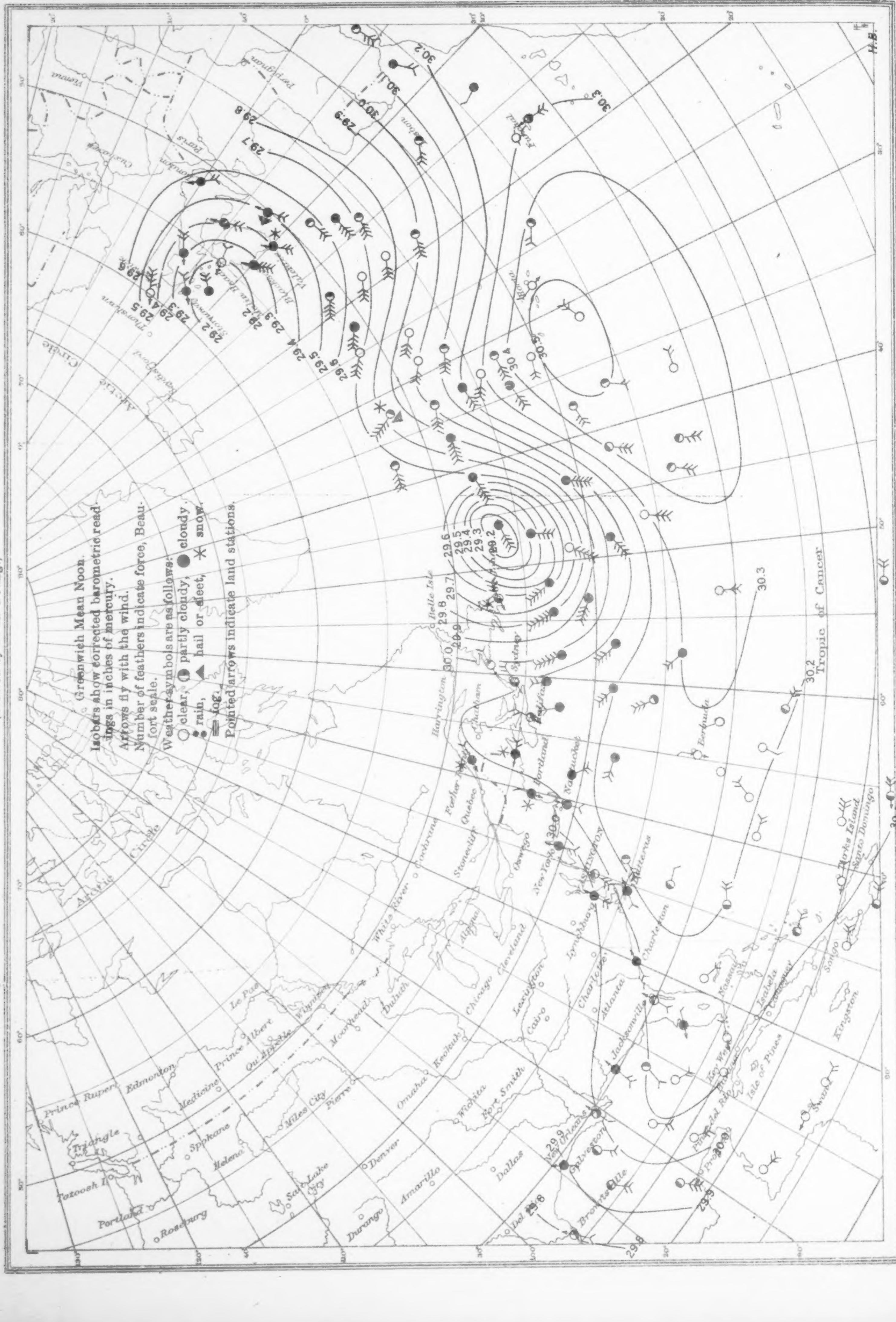


Chart X. Weather Map of North Atlantic Ocean, January 19, 1922.
(Plotted by F. A. Young.)

Chart XI. Weather Map of North Atlantic Ocean, January 20, 1922.

(Plotted by F. A. Young.)

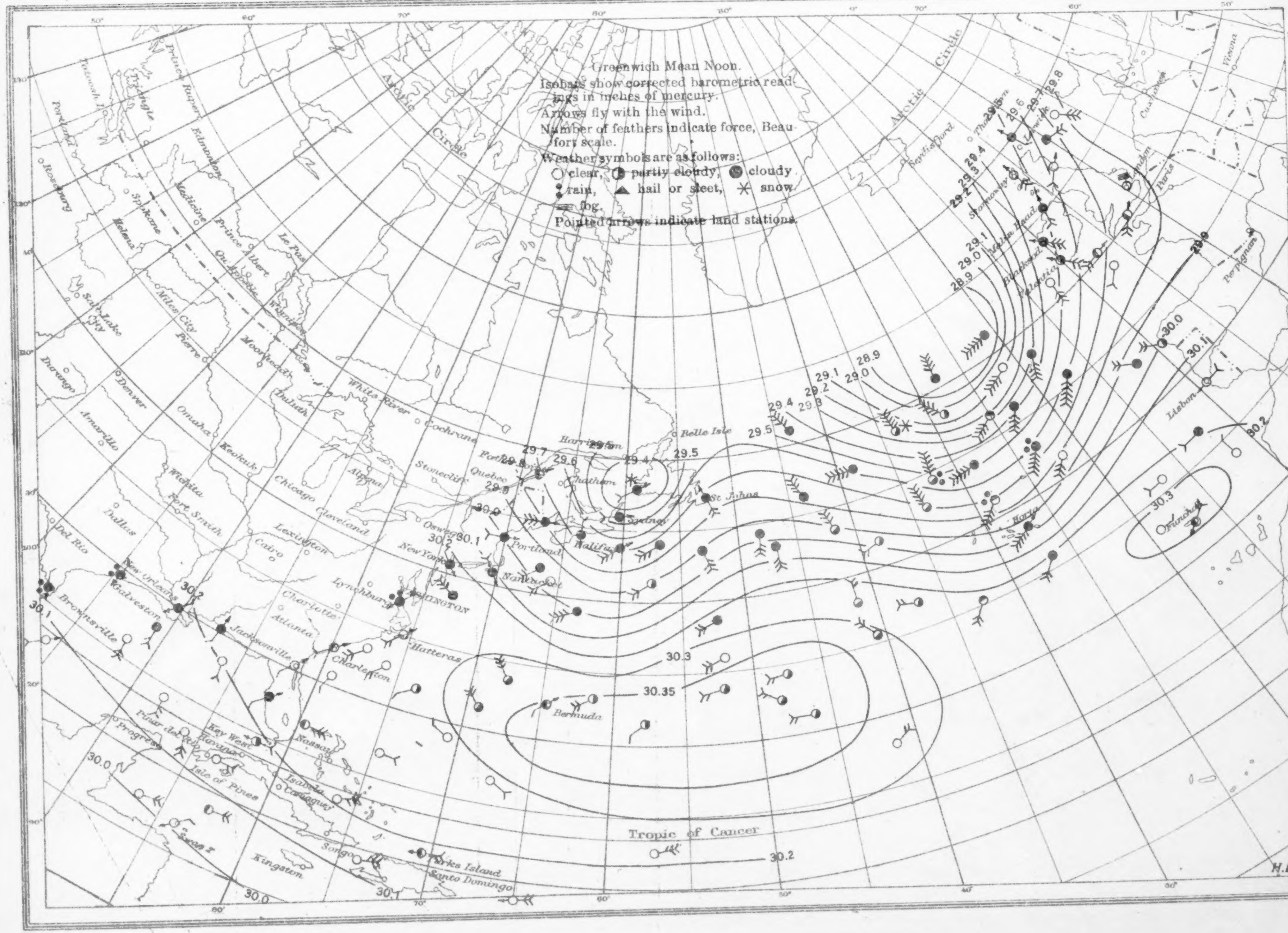


Chart XII. Weather Map of North Atlantic Ocean, January 21, 1922.

(Plotted by F. A. Young.)

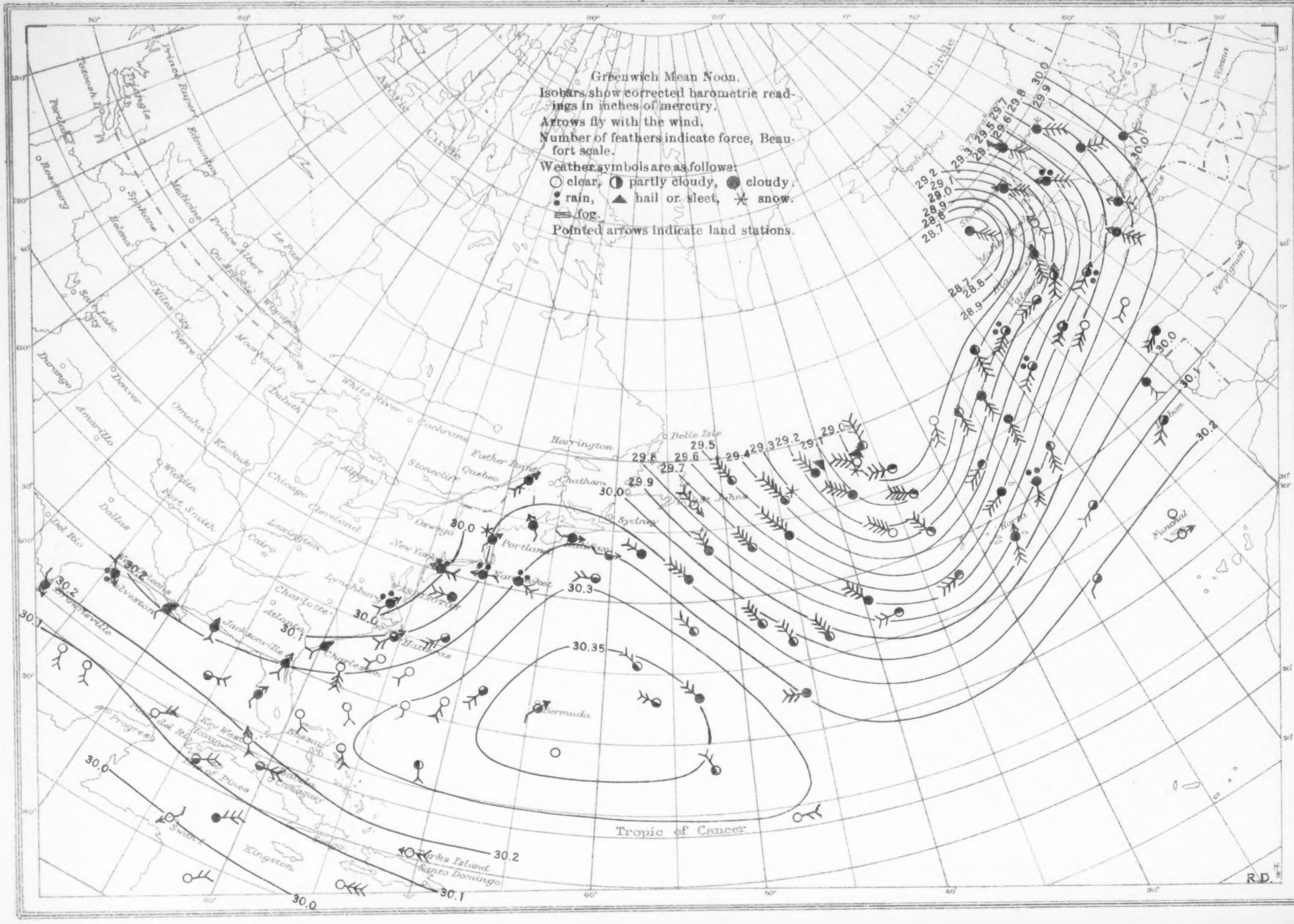


Chart XIII. Weather Map of North Atlantic Ocean, January 22, 1922.

(Plotted by F. A. Young.)

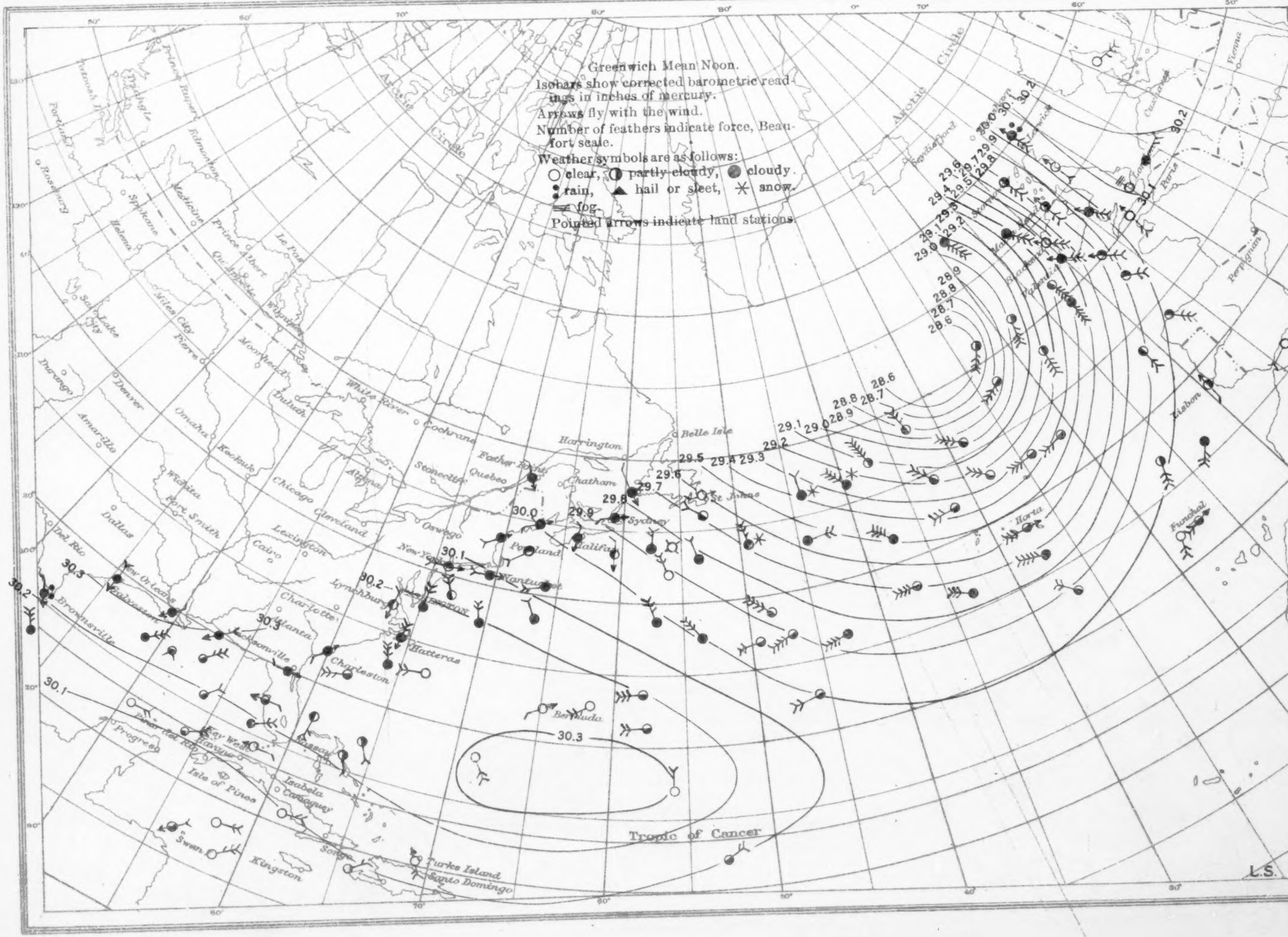
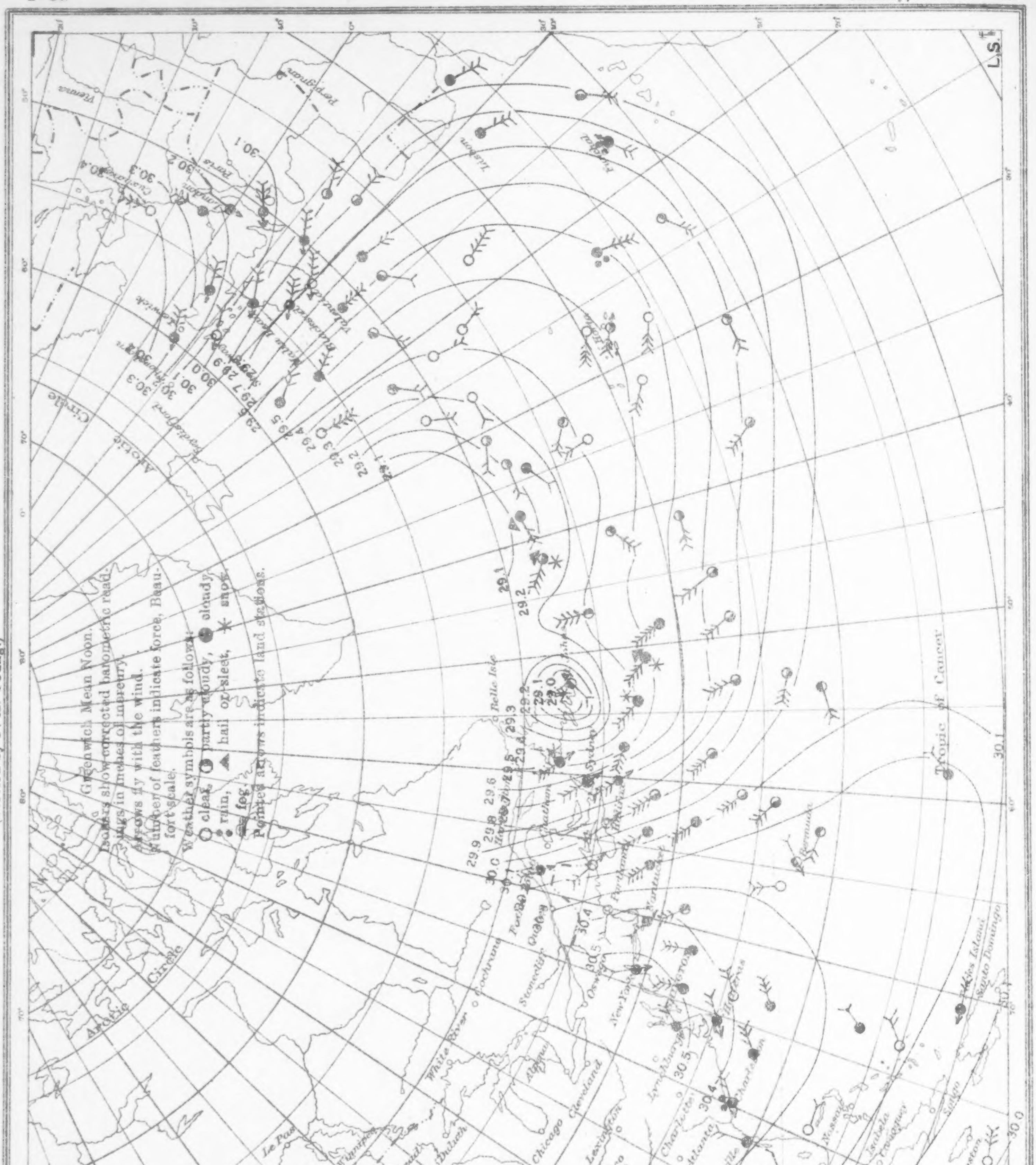


Chart XIV. Weather Map of North Atlantic Ocean, January 23, 1922.
(Plotted by F. A. Young.)



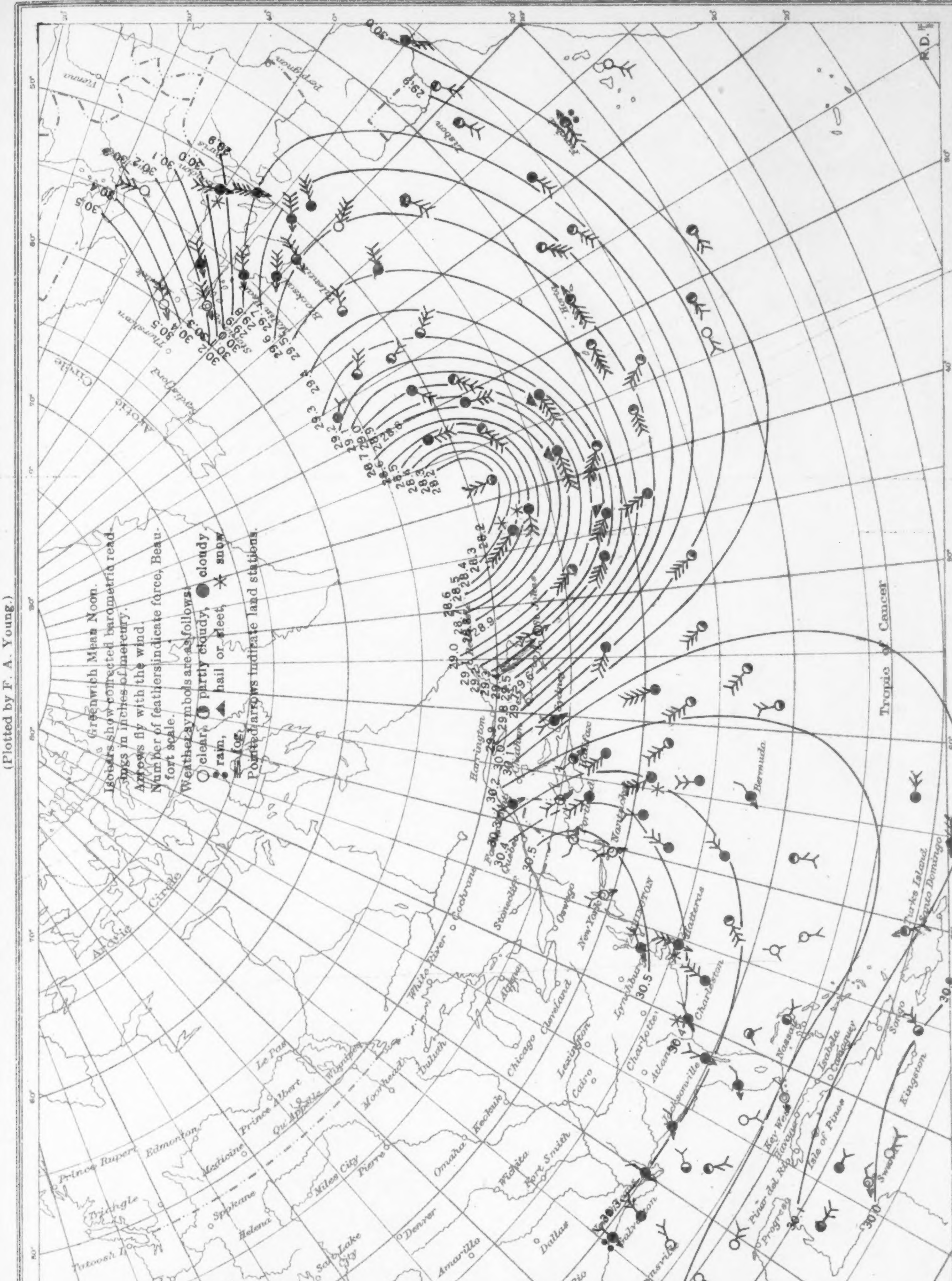


Chart XV. Weather Map of North Atlantic Ocean, January 24, 1922.
(Plotted by F. A. Young.)

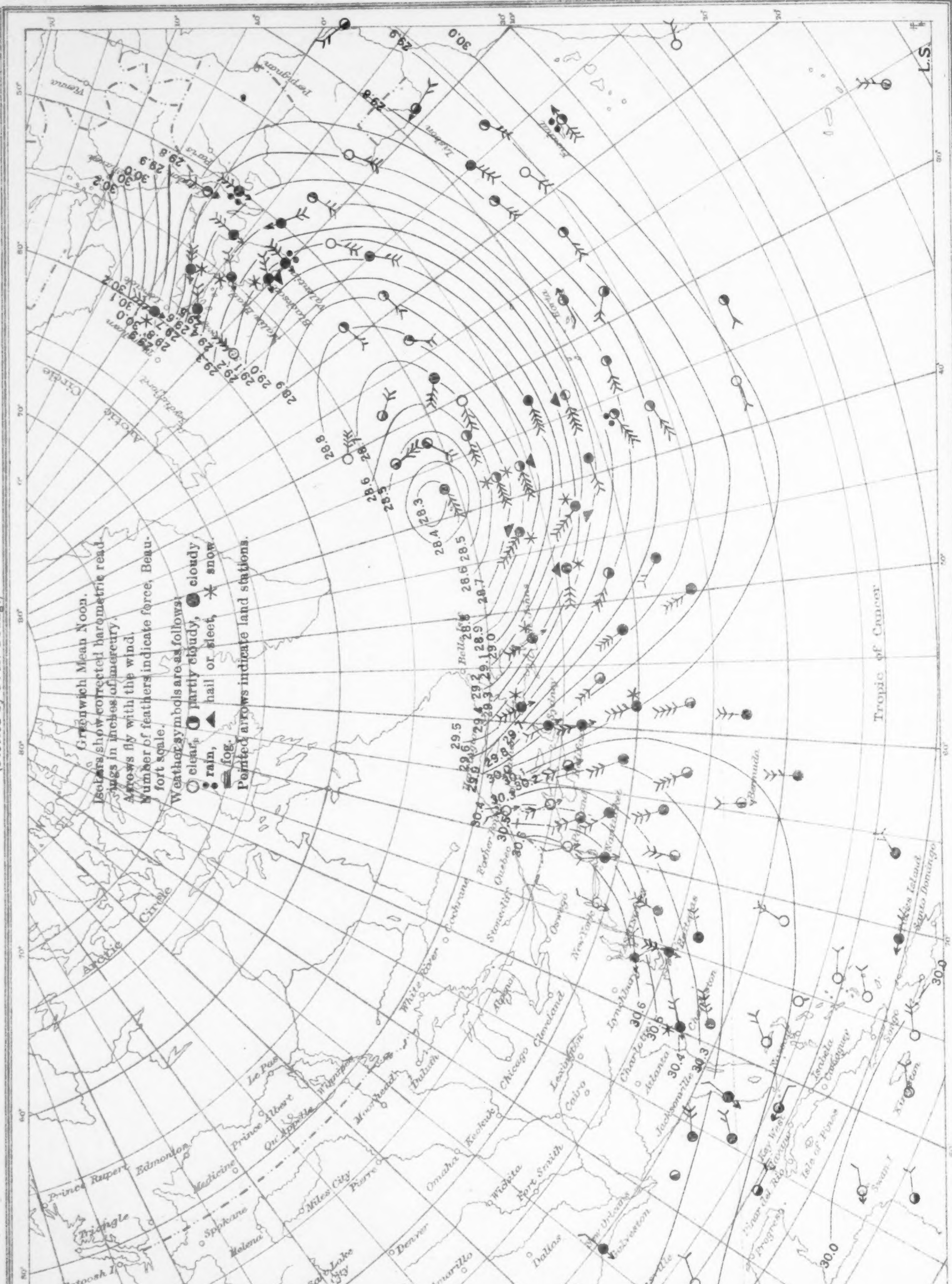


Chart XVI. Weather Map of North Atlantic Ocean, January 26, 1922.
(Plotted by F. A. Young.)

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JANUARY, 1922.

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